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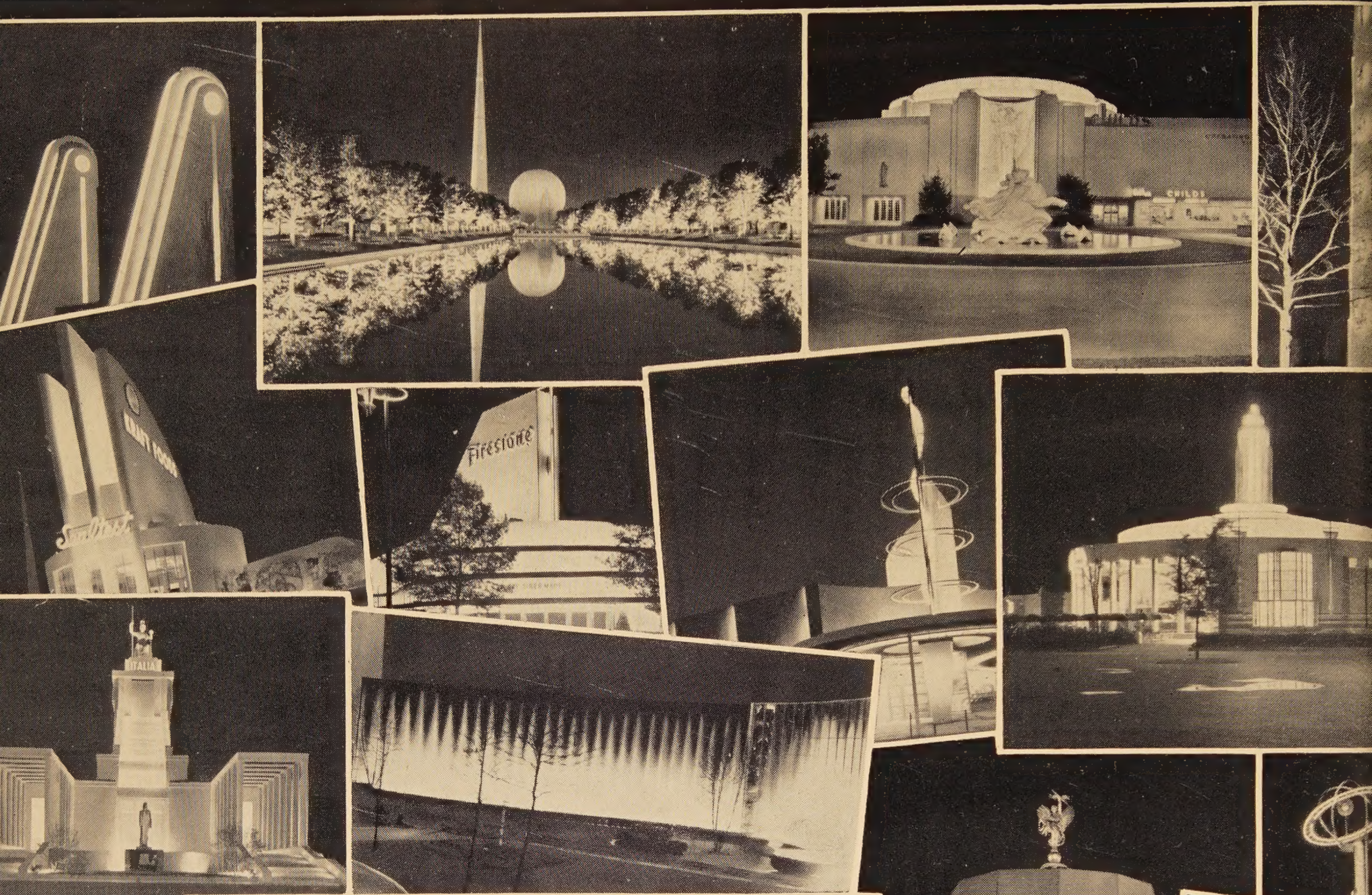

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Electrical Engineering

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for May 1940—

The Cover: Searchlight beams form a canopy over the Court of Peace and Lagoon of Nations at the New York World's Fair, which opens for its second season May 11. Fair illumination, which utilizes new light sources and new materials, is described in this issue.

Photo courtesy General Electric Company

Transactions Section (Follows EE page 218; a preprint of pages 257–320 of the 1940 volume)

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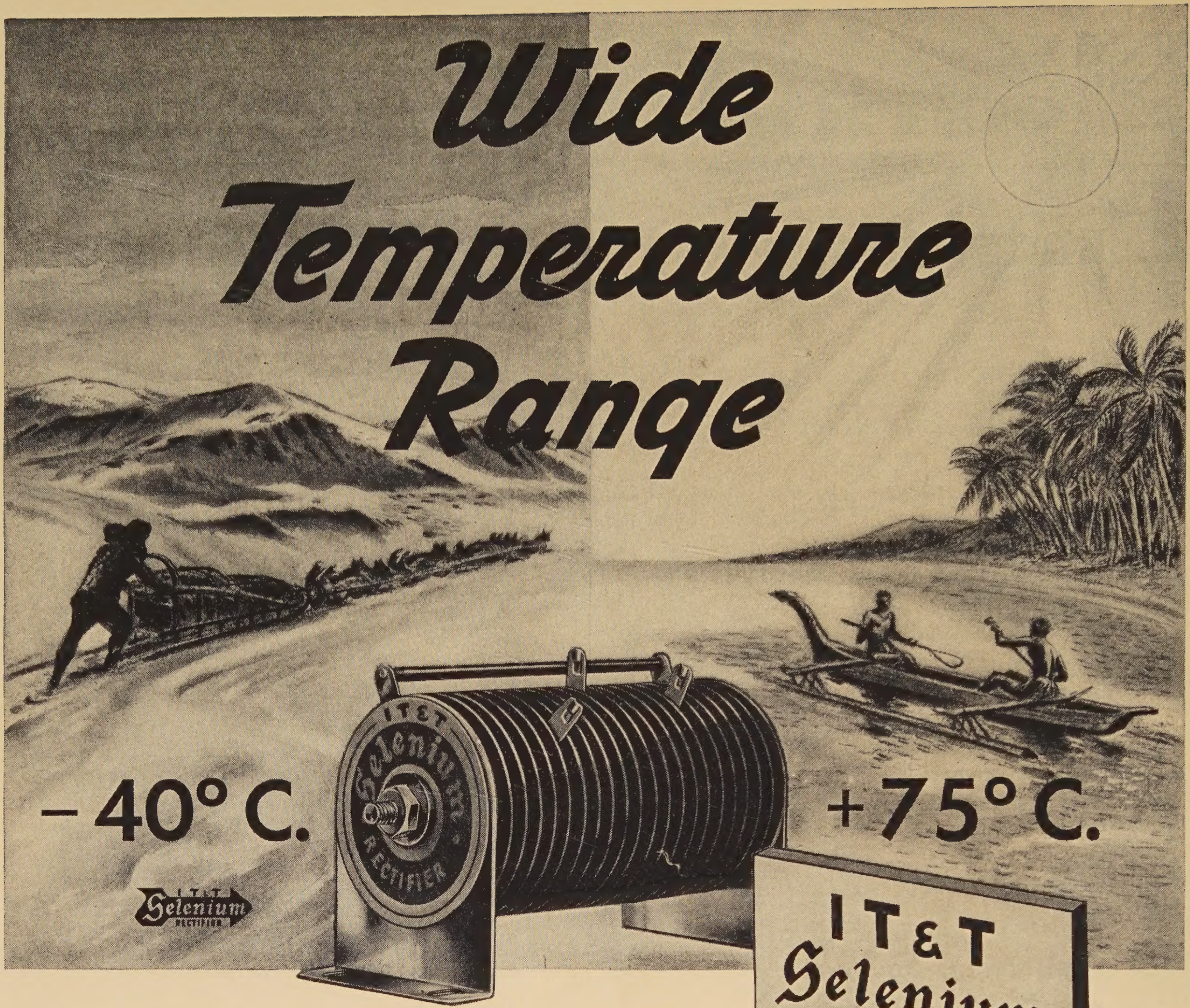

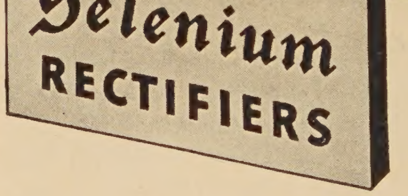

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Figure 1. An air view showing most of the 1,216-acre area of the New York World's Fair, and essentially all of the main exhibit area. The focal points marked are: (A) Court of Peace, government area; (B) Lagoon of Nations fountain; (C) Constitution Mall, with the Four Freedoms plaza (toward the Lagoon) and the heroic George Washington statue facing the Manship fountain and the Perisphere; (D) Theme Center with surrounding plaza; (E) New York City Building, one of the permanent structures; (F) transportation zone, marine and air at the right, automotive at the center, railroads at the left; (G) Bowling Green plaza; (H) Court of Communications; (I) Court of Power; (J) Plaza of Light, electrical-manufacturing and utilities zone; (K) amusement zone starts here and extends to the right. To help readers to orient themselves, the points from which the eight color views were photographed are indicated by numerals, which correspond to the plate numbers

Lighting the New York World's Fair

RICHARD C. ENGELKEN*
MEMBER AIEE

THE CONVERSION of more than 1,200 acres of salt marsh and waste land into the New York World's Fair, with its stimulating review of the world of today and its effective preview of the "World of Tomorrow," was a remarkable achievement, accomplished within the short span of three years. In this $150,000,000 transformation, electric light played a major role. Also, the Fair provided the stimulus that brought from the laboratories into commercial production some of the most significant developments ever made in the field of artificial illumination.

The magnitude and magnificence of the New York World's Fair resulted from the combined efforts of many minds and countless hands, all deserving of commendation. Accomplishments, however, mirror capable direction, for which special mention is made of Chairman Stephen F. Voorhees of the Fair's Board of Design, and Colonel John P. Hogan, chief engineer and director of construction. Illumination was headed by Bassett Jones, consulting engineer to the Board of Design, working with J. S. Hamel and the author as lighting consultants to the construction department. The problem of developing the spectacular displays for the Fair was delegated to a Committee on Displays which reported to the Board of Design. This committee was headed by Bassett Jones, and included Professor Jean Labatut, design; Howard Cooper, hydraulics; and the author, lighting. Operation of spectacles was headed by A. K. Morgan, director of displays.

GENERAL FEATURES

The exhibit area (figure 1) comprising about 1,000 acres, contains more than 200 structures, most of which are windowless exhibit buildings. A zoning and color scheme adopted prior to construction insured architectural unity, and harmony of plan, design, and treatment throughout the whole area. Seven classified zones (foods, governmental, distribution, communication, transportation, community interests, and business administration) are distributed around the Theme Center, with streets radiating from the center and crossed by circumferential avenues. The color scheme, also zoned, but on a basis of aesthetic values rather than occupancy zoning, is co-ordinated with the physical layout. Starting with white at the Theme Center, color treatments of red, blue, or gold radiate outward with progressively more saturated hues. Adjoining hues blend circumferentially along the avenues. By virtue of the proper selection of accents and relief tones, each structure presents a color scheme of interest in itself as well as appropriate to the general picture. The illumination was so fitted into this scheme as to maintain the basic pattern by night as well as by day, but with a new and added interest and charm after sunset (see color plates).

Thus illumination and lighting effects became definite elements in the architecture of Fair buildings. As part of the general plan, the exterior surfaces of the buildings themselves serve as major sources of illumination for adjacent street and plaza areas (figures 41–56; color plates). Brightly lighted entrances, niches, and murals, and backlighted plaques aid in effectively achieving this result. With few exceptions, street lights are used to complete the decorative effects rather than as primary sources of illumination (figures 68, 69).

In building interiors, unobtrusive built-in fixtures in general provide simple decorative effects and good aisle lighting with increased intensities at entrances and exits (figures 57–67). This allows exhibit lighting to be arranged to suit individual requirements.

To give the Fair a pleasingly varied skyline at night and to produce a desirable air of festivity, several tall and brilliantly lighted architectural features such as the pylons were provided for in the illumination scheme (color plates and figures 32–40). Also, the various courts and plazas contain suitable small architectural forms combined with the elements of water, light, and flame to produce scintillating animated effects by virtue of the combination of new elements and materials rather than by mere cyclic color variations. Finally, there were the outstanding "spectacles": the Perisphere-Trylon, Constitution Mall, the Lagoon of Nations, the Court of Peace with its canopy of searchlight beams, and the combined light and fireworks display in Fountain Lake in the amusement area.

Obviously the successful completion of such a gigantic plan required not only the most exacting co-ordination and the closest co-operation among the many architects, engineers, constructors, landscapers, and others involved, but also the creating of new structural forms and new types of lighting equipment. To provide the necessary focal point for technical co-ordination, a test laboratory was established on the Fair grounds in the earliest stages of its development. This served as a medium of contact for the many different interested agencies, and also afforded facilities for research and the study of illumination sources and their possible uses.

Experiments performed in this laboratory served as a stimulus for the commercial development of many new light sources which at that time were found only in the lighting research laboratories. Also many entirely new lighting devices were designed there for the effective application of these new sources. Typical instances are the now well-known low-voltage fluorescent lamp and the high-intensity mercury capillary lamps, which were first used extensively at the New York World's Fair. Architectural

* Member of the firm of Morgan, Hamel, and Engelken, lighting consultants to the New York World's Fair 1939.

elements to utilize new and existing light sources also were developed, or inspired by scale models giving a visible concept of their possibilities.

To insure architectural harmony and unity of effect, all general structural plans, including exterior lighting for private exhibit buildings as well as Fair projects, were first submitted for approval to the World's Fair Board of Design. Thereby the master plan was consistently sustained.

Space limitations preclude adequate description of any appreciable proportion of the many points of engineering and illumination interest throughout the Fair grounds. Therefore, the scope of this article is limited primarily to the "spectacles" which constitute the backbone of the "picture" presented by the Fair at night, and secondarily to typical details embracing the effective application of new light sources, including the material and equipment involved in those applications.

Theme Center

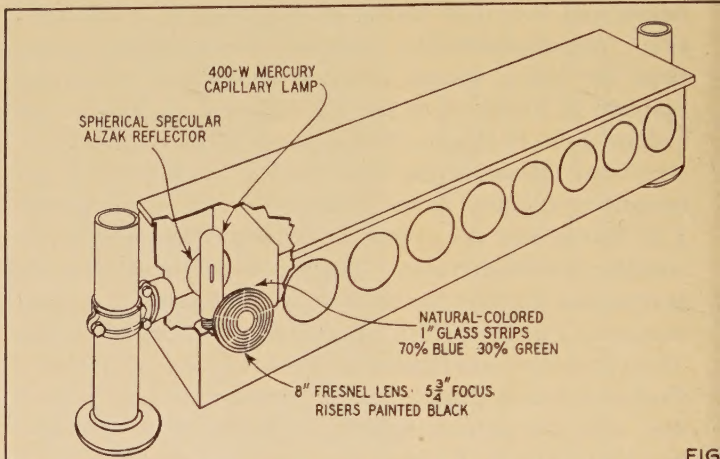
Because of the importance of the Perisphere-Trylon Theme Center in the general scheme of the Fair, special efforts were exercised to make it as unusual in its nighttime illumination, as it is unique in daytime by virtue of its novel architectural design (plates II and IV). Aside from aviation warning lights at its apex and at points on its sides, the 700-foot Trylon is illuminated only by spill light from adjacent structures.

The Perisphere, a 180-foot spherical structural part of the Theme Center, presented a lighting problem of unprecedented nature and proportions. The illuminating-engineering job of making an appropriate and attractive nighttime spectacle out of this huge ball paralleled the mechanical-engineering job of delicately poising a 4,600-ton steel-framed concrete "bubble" over a shallow mirror-pool of water. The exterior lighting problem involved facilities for flooding this sphere with suitable intensities of either amber, red, or blue light, and the further problem of projecting moving cloud patterns over its three-acre surface (plate IV). Even the floodlighting had to be accomplished by lens-controlled light-beam projection, because the roofs of the nearest buildings on which lighting units could be placed were some 250 feet away (figure 13).

Based upon extensive experimenting with scale models using a six-foot-diameter wooden ball painted white as a model, the lighting sequence adopted is an amber light thrown on as dusk approaches, subsequently fading into a sunset red, and then into a deep evening blue after dark. Water jets underneath the Perisphere, supplemented by blue floodlights beneath the surface of the reflecting pool, and white cloud-shapes projected onto the Perisphere combine to impart the desired effect—that of a translucent bubble poised over the surface of its reflecting pool.

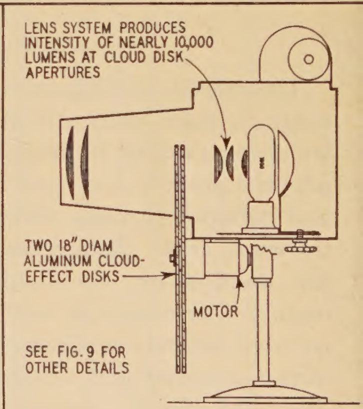
Three types of projectors are used for the exterior floodlighting of the Perisphere. For the amber and red light, projector units of the Fresnel type fitted with 5,000-watt incandescent lamps are used (figure 5). Banks of 8 of these units, 4 red-beam projectors and 4 amber, are mounted on the roof of each of the 5 buildings selected as projection points, making a total of 40 units (figure 2).

The production of an adequate intensity of blue light on the extensive surface of the Perisphere presented a major problem in illumination and required the development of a new light source and related equipment for its use. Because of the blue deficiency of an incandescent light source, a 400-watt high-intensity short-arc mercury capillary lamp was developed and special projectors were designed for the



FIG

Figures 2–5. The three-acre exterior surface of the Perisphere is illuminated in any of three colors by 30 nine-lamp projectors using mercury capillary lamps with Fresnel lenses ribbed at the back to give a 10-degree horizontal spread (3) and 40 5-kw incandescent projectors, 20 red and 20 amber (5); drifting clouds are produced by 30 2.5-kw incandescent cloud projectors (4). This equipment is installed on the roofs (2) of five buildings around the Theme Center



FIG

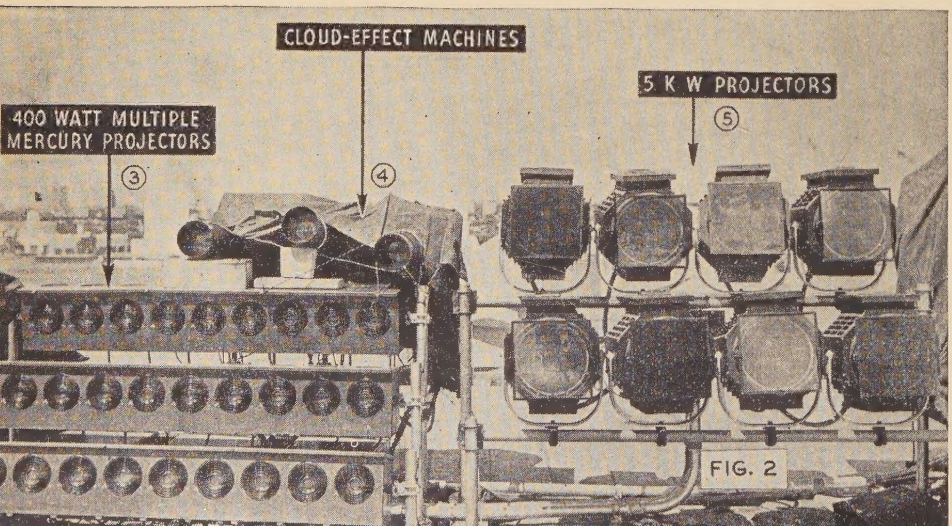
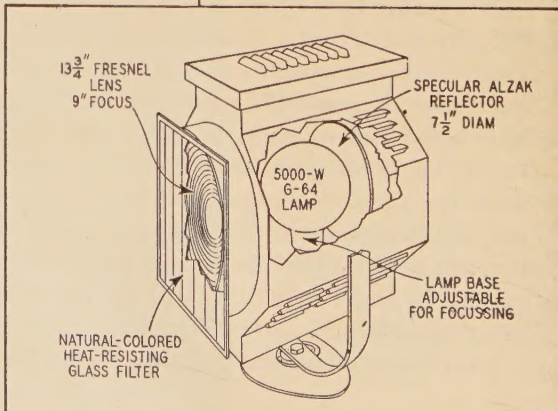


FIG. 2



FIG

job. Each of these projector units accommodates nine of the new 400-watt mercury lamps, with suitable light-control optics (figure 3). Blue light for the underside of the Perisphere is provided by 96 blue-filter submerged projectors (similar to those of figure 17) using the new 100-watt mercury capillary reflector lamps.

Cloud projection, relatively simple with the 6-foot model, became another major problem when applied to the three-acre surface of the 180-foot Perisphere. To produce the misty cloud effect desired, an illumination intensity of nearly 10,000 lumens through the projector gate and objective lens is necessary. The resulting intense heat in the projector gate precludes the use of any photographic emulsion or ordinary painted slide; in fact, even the regular mica cloud-machine disks buckled and cracked from the heat. By experiment it was found that aluminum disks containing irregularly shaped apertures backed by small pieces of mica could be used, and that a heat-resisting paint could be applied to the mica to provide gradation in shadows. In the final installation, two such

Figures 6–12. Inside the Perisphere (11, 12) "Democracity" is illuminated by a continuous strip of floodlight projectors underneath the lower platform (6); another continuous strip illuminates the horizon (6). Sky lighting is provided by a separate row of projectors (10); moving clouds are thrown across the sky by special cloud projectors (9) and their companion shadows across the landscape by special shadow projectors (8). The night scene is complete with stars (7) representing the principal constellations as they appeared in nature. The motion-picture murals (12) are produced by ten special projectors (11, unlabeled unit)

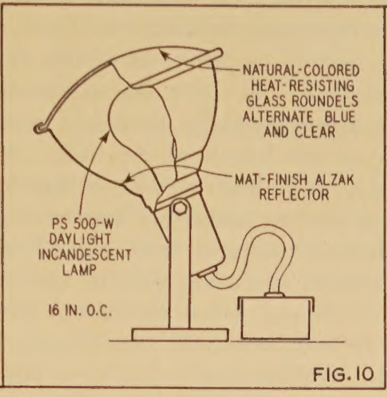


FIG. 10

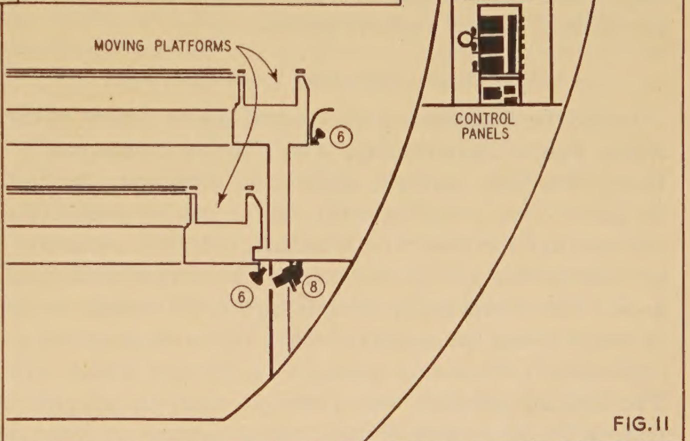


FIG. 11

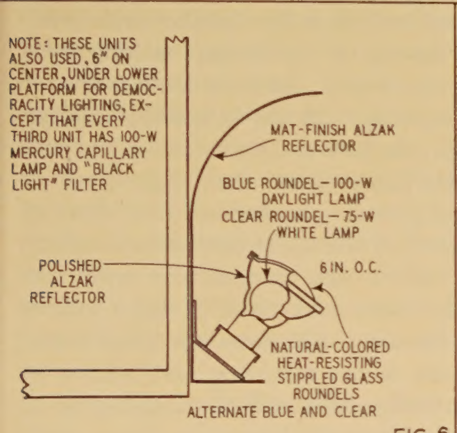


FIG. 6

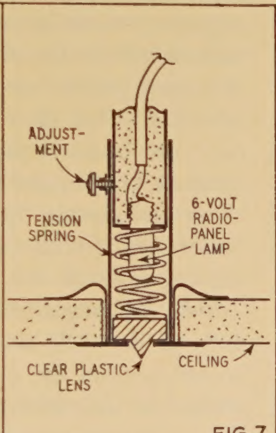


FIG. 7

Courtesy Henry Drey

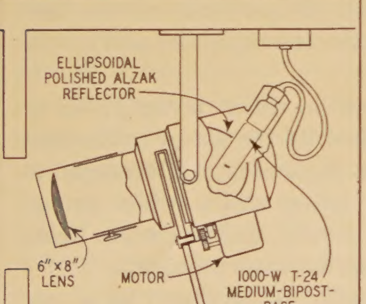


FIG. 8

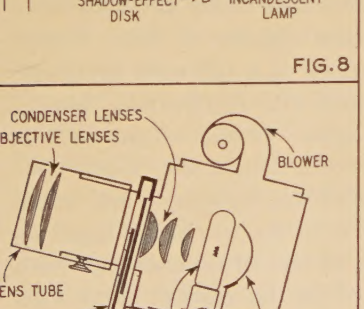


FIG. 9

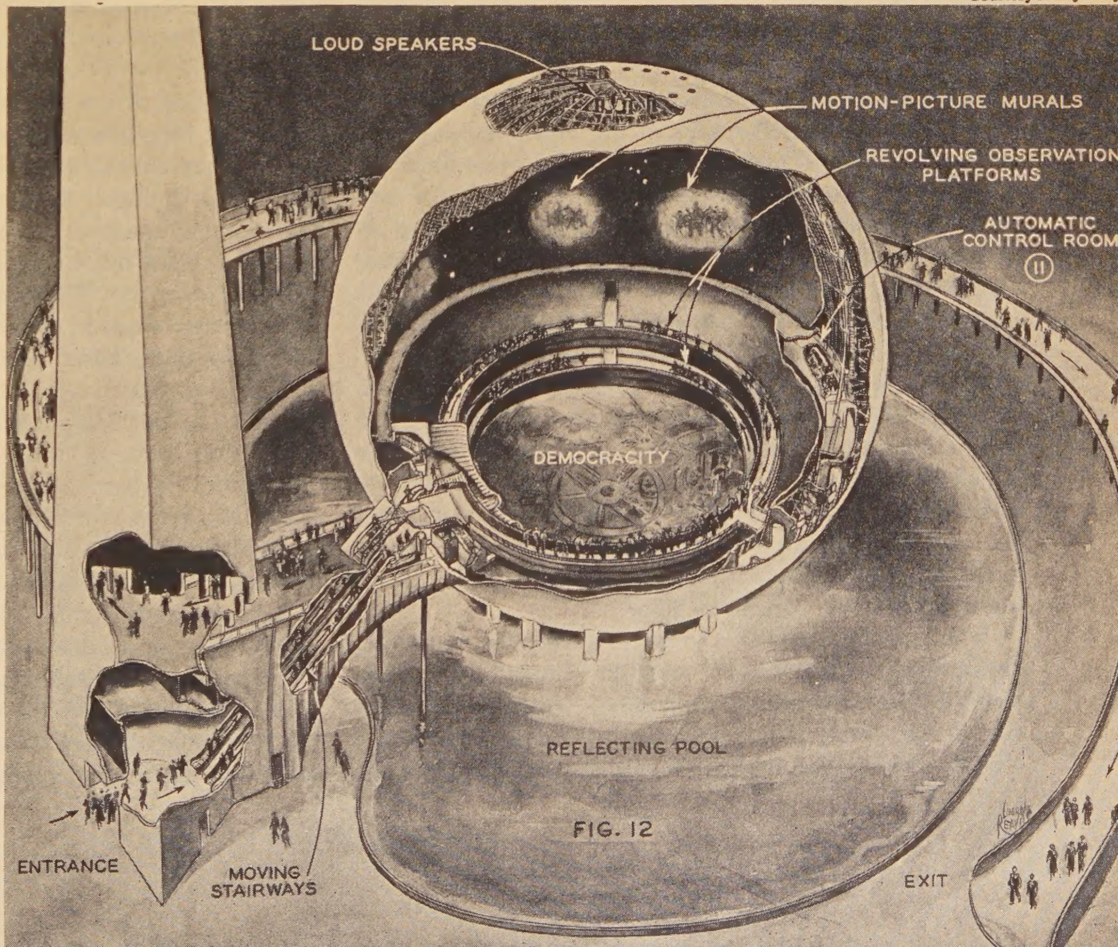


FIG. 12

mica-backed aluminum disks rotating at different speeds are used in each projector (figures 2, 4). Thirty of these cloud-projectors, each using a 2,500-watt high-color-temperature tungsten lamp, are used with overlapping patterns to cover the whole visible area of the Perisphere.

All projectors—amber, red, and blue floodlighting units and cloud machines—are connected to reactance-dimmers and preselective control equipment which permit any cycle of lighting to be used, and provide for automatic control of the 383 kw of exterior Perisphere lighting.

Additional projectors, located on the roofs of the two buildings facing the Perisphere from either side of Constitution Mall, enable special effects to be projected upon the Perisphere area facing the length of the Mall. In 1939 on Edison's birthday, a 75-foot portrait of Edison was projected onto the sphere by additively superposing projected images of identical pictures from these two machines. By similar means, the whole eastern face of the Perisphere became a 180-foot jack-o'-lantern in true color and configuration on Halloween; the jack-o'-lantern even winked occasionally. Undoubtedly this is the largest colored "movie" ever attempted.

INTERIOR ILLUMINATION OF PERISPHERE

Inside the Perisphere is the central theme exhibit of the whole Fair—"Democracity, The City of Tomorrow"—Henry Dreyfuss' carefully scaled and intricately detailed idealistic city, complete with all necessary supporting environs and facilities for agriculture, industry, commerce, air and surface transportation, and suburban residential area. The viewpoint of the spectator is that which would be secured from an airplane circling this scale model at an equivalent elevation of perhaps 10,000 feet (figure 12). The lighting problem was twofold: first, to provide a realistic 24-hour day-and-night cycle; second, to give the observer the physical impression of being suspended in space with the earth beneath him and the sky overhead extending to distant horizons.

The illumination problems encountered in the accomplishment of the desired results in the Perisphere interior, which is actually a large integrating sphere, were found to be even more exacting than those encountered on the outside. Frequent, rapid, and smooth changes in lighting effects are required, as well as exact synchronization of these visual effects with recorded sound effects ranging from voice to music; all automatically controlled in predetermined accurately timed repetitive cycles.

Spectators enter the exhibit through the base of the Trylon, and by means of the two longest (96 feet and 120 feet) electrically operated moving stairways built to date are carried up either 48 feet or 60 feet, respectively, to the lower or upper of two continuous electrically operated moving platforms that carry the spectators at a predetermined speed around the inside periphery, just below the equator of the Perisphere globe.

If the spectator happens to arrive during the day scene, he sees below him in bright "sunlight" the miniature scale City of Tomorrow and its supporting countryside stretching to far horizons and blending realistically with the "sky." Above him is the tremendous arched dome of the Perisphere, impressive in its resemblance to the sky, floodlighted unobtrusively in blue, giving the impression of the heavens complete with moving clouds and their companion shadows drifting across the buildings and landscape. The scene gradually changes, shadows actually lengthen to afternoon proportions, daylight fades smoothly and realistically into dusk, and the sky gradually becomes a midnight blue. Above in the seemingly limitless depths of the vaulted dome appear stars, including those accurately representing the major constellations as they appeared in nature on the night of April 30, 1939, when the Fair first opened. Night clouds drift across the sky. In the meantime, lights have appeared gradually and unobtrusively in the city, in the neighboring industrial area, and in the nearby community of small homes. As the night cycle progresses, the countryside becomes dark except for a few lighted windows and the illuminated highways.

Against a background of appropriate music, the voice of a commentator explains the symbolism of the changing scenes, and helps the spectator to note and follow the many and realistic changing effects. At one stage of the sequence, voices become audible in the distance and simultaneously from far off among the clouds approaching hosts of singing people become visible. As they come nearer, it is evident that they represent all the inhabitants of the city—the business men, the farmers, the workers, the professional people, and the housewives. As the groups draw closer and assume their greatest proportions, they descend out of sight behind a bank of horizon clouds as the concluding sequence of one cycle in the continuously repetitive "show." Immediately dawn and then daylight follow, and another cycle has started. The time cycle of spectator transit around the globe on the revolving platforms is so related to the automatically controlled day-night cycle of the exhibit that all spectators may view a complete cycle between the time they step onto the platform and the time they find themselves back to the starting point and on the way out.

The lighting of the sky dome in either daylight blue or deep night blue is accomplished by the use of continuous rows of concealed strip lights (figures 10, 11) arranged in two circuit groups—a blue group and a white group. The blue lights are on continuously, and the white lights vary from black-out to full brilliance as required.

The lighting for "Democracity" is produced by a continuous row of strip lights mounted under the structure that carries the lower platform (figures 6, 11). Every third unit in that continuous row is a 100-watt short-arc mercury capillary lamp equipped with appropriate "black-light" filter. These "black lights" remain on during the entire show, but are effective only during the "night" period of the cycle, when the windows, highways, and other apparently "illuminated" parts of the model are made to fluoresce under the influence of the ultraviolet radiation from these lamps by virtue of the fluorescent paint with which these parts are coated. Thus, the "lighting" in Democracity at night actually is entirely fluorescent.

Principal features of the special equipment required for the Perisphere interior "show" are the ten specially designed projectors that operate in synchronism to produce

the 18- by 30-foot motion-picture "murals" in the "sky" (figure 12). These machines use Bantam-size glass slides in place of the successive film frames of ordinary motion-picture projectors. In each machine, a series of these slides is projected through four optical systems in succession. The slides are mounted on two 50-inch ring gears which revolve within the optical systems. Through a shutter arrangement in front of the objective lenses the slide images are cross-dissolved from one optical system to the next, producing a smooth motion with 8 images per second (as compared with 16 or 24 for standard motion-picture projectors). As intensity of light on the screen remains constant but for absorption by the slides, there can be no flicker regardless of the number of frames per second. It is a noteworthy achievement that the projections from the four individual optical systems of each machine can be registered so accurately in superposition on a screen 165 feet away as to produce a composite result of smooth and realistic motion. Each projector uses four 2,500-watt 65-volt lamps having differentially wound filaments similar to those used in the cloud machines, and is fitted with $f/2$ objective lenses of 8-inch focal length, the largest ever built for such a purpose. To keep all ten projectors in perfect synchronism, each is driven by a Selsyn motor equipped with a mercury damper; all in turn are driven by a common Selsyn generator.

The cloud projectors for the Perisphere interior are similar to those already described for the exterior, with the exception that a lower illumination intensity at the gate permits the use of tempered glass cloud slides (figure 9). Two six-inch cloud slides in each machine are mounted in frames eccentrically driven to produce a rolling effect of the projected clouds.

The entire Perisphere theme show—including the time, music, earth, sky, and voice elements—is entirely automatic, and timed to split-second accuracy. The various operations, including the many lighting circuits and ten special motion-picture projectors, involved in a typical operating cycle of 336 seconds are under the control of motor-driven cams which operate through one revolution and then stop for a few seconds awaiting the initiating impulse which starts each new show cycle. The single signal impulse which initiates each new cycle automatically originates from a notch cut in the sound film. Thermionic tubes constitute the nerve center of this equipment, controlled by the cams and in turn regulating saturable-core control reactors in each of the lighting circuits.

THEME-PLAZA ILLUMINATION

The desired composition of the vista looking toward the Theme Center from any of the five thoroughfares radiating therefrom involved the problem of preserving the full effect of the blue light and cloud effects on the Perisphere. In general, this result was accomplished by keeping all objects of relatively high brightness out of the field of view, and by effecting as much control as possible over the quantity of stray or spill light that would tend to fog the atmosphere and thus dilute the color effect of the Perisphere. The levels of illumination on the exteriors of exhibit buildings were kept low in the vicinity of the Theme Center, grading to higher intensities farther away. Brightly lighted pylons, fountains, and other accents were kept at the opposite ends of connecting courts and thoroughfares.

Around the Theme Plaza itself, the illumination of building façades is accomplished chiefly through the use of back-lighted sculptures (figure 49). These provide spots of visual interest and also provide adequate illumination for adjacent walks. Remaining illumination, aside from reflected light from the blue sphere itself, is provided by luminescent trees activated by mercury light.

Constitution Mall

Connecting the Theme Center and the Lagoon of Nations and constituting a portion of the main backbone of the Fair is Constitution Mall, a 2,000-foot tree-shaded esplanade built around a series of rectangular lagoons and reflecting pools (figure 1). Principal architectural feature of the Mall is the 55-foot statue of George Washington, which is lighted only by spill light from structures on either side of the esplanade. Nevertheless it is as prominent and effective a part of the nighttime picture of Constitution Mall as it is of the daytime vista. The statue is the work of the noted sculptor James Earl Fraser, designer of the AIEE Edison Medal. Other architectural features of the Mall are the Manship sundial, fountain, and associated sculpture group just off the Theme Plaza, and the "Four Freedoms" statues (representing freedoms of press, religion, assembly, and speech). Like the Washington statue, the Freedoms statues are illuminated only by spill light.

The lighting of the Mall creates a strikingly beautiful night effect (plates I, II). Along either side of the Mall for its entire length is a double row of 50-foot luminescent trees which constitute an effective part of the view after sundown and at the same time provide all illumination necessary for the main walkways. Supplementary lighting for walks adjacent to exhibit buildings is provided by light from building entrances, and from illuminated murals, plaques, and niches on the sides of the buildings.

Underneath each of the trees along the Mall, one of the new 250-watt short-arc mercury capillary lamps is set into the ground, in a suitable fixture fitted with a cylindrical metal collar which projects above the ground line for the dual purpose of controlling the side light and of protecting the fixture from physical damage (figures 13, 19). Under the influence of the peculiar radiation from these flood lamps, the leaves, twigs, and branches of the trees become luminous with a soft greenish glow, producing a beautiful effect. The same type of lighting also is applied to the trees in the Theme Center Plaza, the Court of Communication, and the Court of Power (figure 1). In all, some 360-odd trees are so lighted.

WATER LIGHTING

Another attractive feature of the lighting composition of the Mall is a variety of water-lighting effects, chief of which is the animated play of colored light and water in the Manship fountain at the head of the Mall (figure 13). The Manship fountain and associated sculptures are in-

tended to connote the passage of time (indicated by the sundial itself) and the moods of time affecting the human race. This latter effect is simulated by the alternate floods of gold light and blue light which seem to pour in repetitive cycles from three apertures in the abutment of the sundial terrace and flow in successive waves down the entire length of the pool in the layer of mist which overlies the pool. These effects are created by a cyclic play of light upon three columns of water which pour from the sundial abutment and upon curtains of mist overlying the pool. During the operation of the fountain, the columns of water flow continuously, the volume magnified by an ingenious arrangement (figure 16) that produces in actuality a relatively thin-walled cylinder of water 20 inches in diameter. Waterproof lighting units built into the central portion of the discharge "megaphones" of this fountain introduce into each water column alternate cycles of blue and gold light which grade smoothly from dark to maximum brilliance and back to dark for each color. In the pool of the fountain (figure 13) a set of continuous striplights (figure 17), on the center line of each of the three water columns, extends for a distance of approximately 115 feet. Flanking each of these striplights is a

Figures 13–19. The main esplanade of Constitution Mall (13, plate I) consists of reflecting pools lined with small illuminated water jets (17, plate II) and enlivened by several small back-lighted cascades (18). Broad tree-shaded promenades along either side are illuminated by the trees themselves, which luminesce under the influence of radiation from mercury capillary units, one underneath each tree (19). At the west end of the main esplanade is the Manship fountain with special mobile effects produced with water and light (13, 16, 17). Various illuminated murals (15) add decorative touches along the Mall, and in other parts of the grounds. The principal plazas are lighted by special projector standards (14) which concentrate the light on the ground, keeping it out of the range of vision

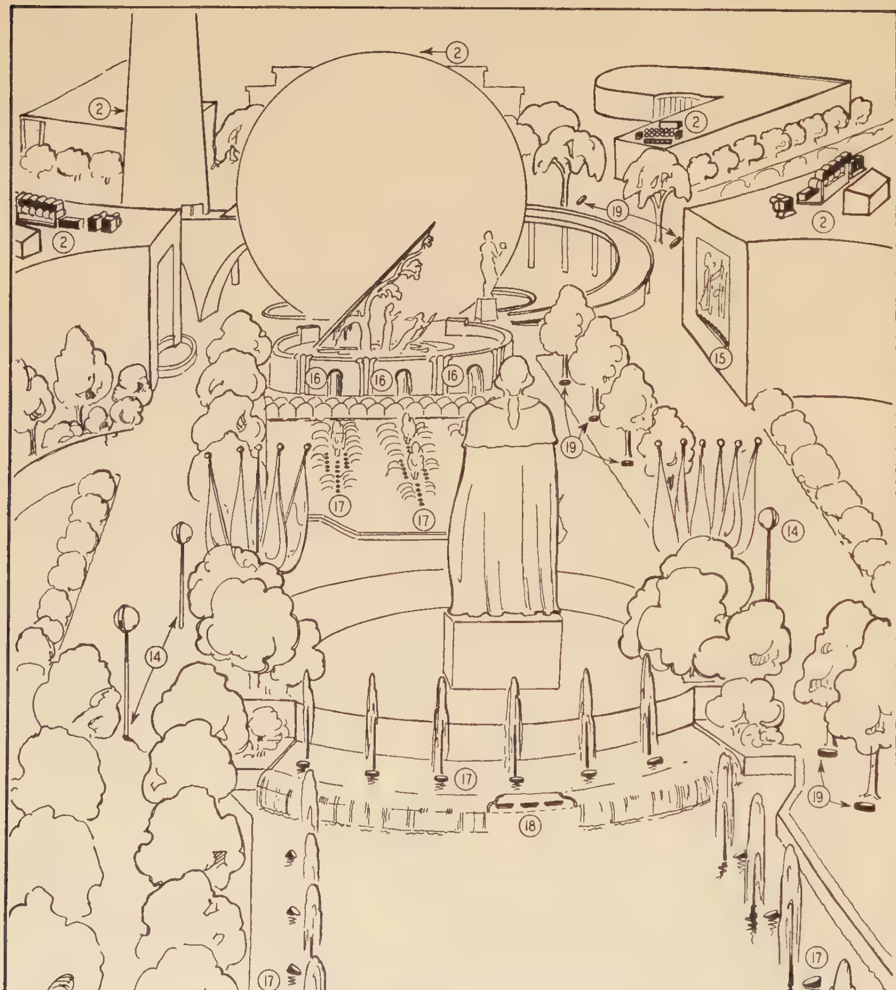


FIG. 13

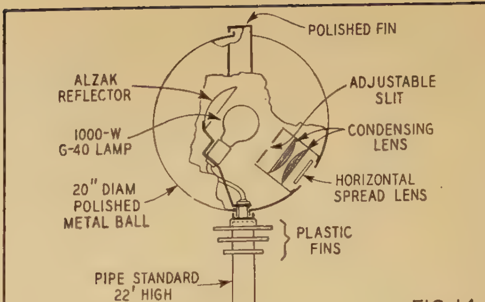


FIG.14

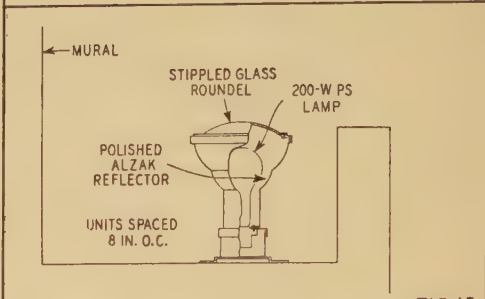


FIG.15

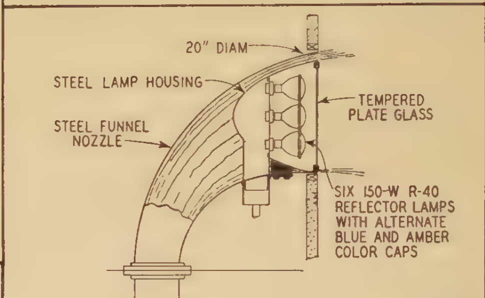


FIG.16

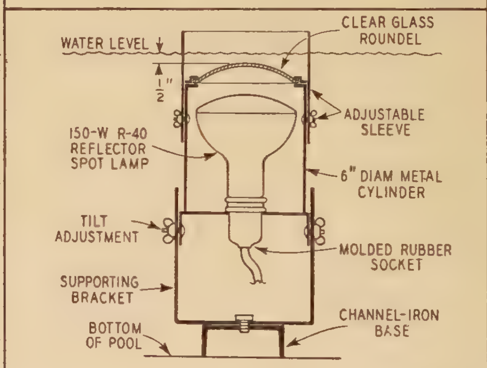


FIG.17

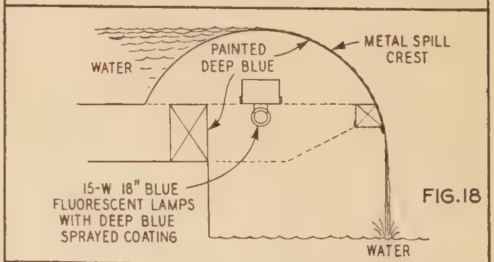


FIG.18

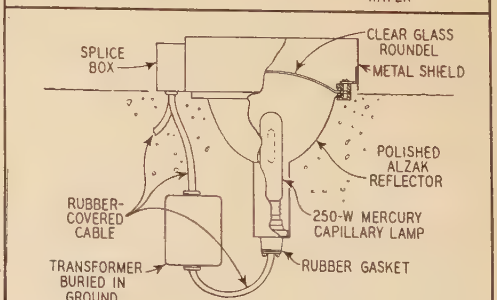


FIG.19

row of atomizer nozzles which produce three parallel spray curtains and a supplementary layer of mist over the pool generally. As in the three main water columns, two colors—blue and gold—are provided in each line of strip-lights by fitting each alternate projector with a gold or blue filter. The alternate cycles of blue and gold light that progress down these strips in accordance with a prearranged sequence are synchronized with the corresponding colors in the main water columns. The two color circuits for the column lights as well as for the associated atomizer strips are connected to a special cycle-dimmer arranged to produce the effect of, first, a flow of one color, followed by a flow of the second color, then a flow of both colors combined. The effect begins with the main column lights and continues down the length of the pool with a rate of color flow of approximately ten feet per second and with alternate colors based on five-second intervals. The control device used is a brush-type flasher operating in combination with a motor-driven bank of variable autotransformers. These control the intensity as well as the switching of the separate color circuits, which are brought out at ten-foot intervals to groups of the striplights.

Along both sides of the center pool of the esplanade group and across the head of the pool at the base of the George Washington statue are vertical water jets projected to a height of about eight feet above the surface of the reflecting pools (plate II; figure 13). Each of these jets is individually lighted from beneath the water surface by a single 150-watt reflector lamp (figure 17). Across the head of the pool at the base of the Washington statue is a cascade electrically illuminated from behind (figures 13, 18). A similar back-lighted cascade heads the next pool of the group. The third pool, nearest the Lagoon of Nations, has no lighting features of itself, but serves rather as a reflecting pool in which the fountain display and the Court of Peace searchlight-canopy are mirrored (plate III).

The two plazas of the Mall—George Washington and the Four Freedoms—are lighted by means of special stanchions (figures 13, 14) topped by lighting units fitted with optical systems which project light down to the surfaces of the roadway and walkway, eliminating dispersion.

Lagoon of Nations Display

Dominant and popular lighting spectacle of the Fair, the Lagoon of Nations combines the elements of water, light, sound, flame, and fireworks in one mammoth display. Regardless of weather the evening performances of this "show" (plates I, VIII) regularly have packed thousands of Fair visitors into every available vantage point from which the spectacle could be viewed. Centrally located in the main exhibit area, the Lagoon forms a pivotal focus of interest, by day as well as by night, flanked to the west by Constitution Mall leading to the Theme Center, and to the east by the Court of Peace with its phalanx of government buildings (figure 1).

The Lagoon is an elliptical pool some 800 feet long and 400 feet wide. This area, approximately five acres, originally was a slough over which a supporting mat covered by a coating of gravel had to be laid. At the center of the pool is a wooden platform 400 feet long and 200 feet wide, mounted on piling and normally about two feet under water. This submerged platform supports the array of piping, wiring, and equipment required by the fountain itself and also supports four cylindrical kiosks 24 feet in diameter and 7 feet high which house groups of sound projectors as well as miscellaneous electric and hydraulic-valve control equipment. The plan view (figure 27) shows the "three ring" arrangement of the fountain and indicates the general arrangement of more than 1,400 water-jet nozzles, 133 gas-flame nozzles, 285 fireworks mortars, and 552 special light boxes.

At the center of each of the three circular sections of the fountain is a group of nozzles capable of projecting a column of water 150 feet into the air. Equally spaced around the concentric rings of each section are nozzles capable of projecting water jets to a height of 75 feet. Each of these 552 heavy-duty nozzles has its own twin-unit projector box for light and color effects (figures 27, 28). Miscellaneous other nozzles provide for a wide variety of water configurations. A border of graceful shape is provided around the triple operating center of the fountain by approximately 1,100 feet of strip lighting which illuminates a spray screen produced by atomizer nozzles (figures 27, 28).

PLANNING AND ARRANGEMENT

The physical arrangement and relationship of these various elements were determined through the medium of extensive studies of small-scale working models, and of experimental equipment both in miniature and full size. In the experiments with full-scale working models, several important observations were made which had a direct influence on the design of the lighting and control equipment. For example, it was found that the effect of mercury-vapor lighting of the tall water jets was especially desirable, not alone because of the rich and intense blues, greens, and other cool shades thus obtainable, but also because of the scintillating and animated "sparkle" imparted to the myriad particles of water by the stroboscopic effects of the mercury light. Also, many interesting and hitherto unobtainable shades of colors were found to be attainable by combining certain of the colors derived from the mercury lamp with other colors derived from the incandescent light sources.

Probably one of the most significant experimental observations was the extent to which color values obtained from incandescent sources were enriched by direct color-filtering of the lamp with its filaments burning at maximum temperature, as compared with color effects produced by blending the primary filtered colors from incandescent sources with conventional dimmer-control and consequent subnormal filament temperatures.

TWIN-PROJECTOR LIGHTING UNITS

The necessity for color control of the mercury light sources led to the development of an effective mechanical color-shifting and dimming device, which, as just intimated, also lends itself effectively to color control and dimming of incandescent light sources. Thus, to provide the range and combination of colors that make the foun-

tain display famous, a special semisubmersible twin-projector lighting unit was developed. Each of these units (figures 21, 22) utilizes a 1,500-watt concentrated-filament incandescent lamp and a 400-watt mercury capillary lamp. Each light source in each unit is fitted with a suitable reflector. Around each reflector is a specially devised six-sided revolving color drum, the sides of which support natural-colored glass filters, open frames, or blank metal sheets, in selected sequence. (The trade term "natural-colored" refers to color throughout the thickness of the filter glass, as compared with surface treatment.) These color drums enable effective mechanical dimming of the incandescent light as well as of the mercury light, and permit not only combinations of various colors of the two sources, but also the use of any of the several colors or tints from either of the two sources independently of the other. The complete twin unit, including incandescent lamp, mercury lamp, and all associated driving and control equipment, is mounted in a waterproof sheet-metal tank approximately 28 inches long, 28 wide, and 27 deep.

Each color drum is separately driven by a three-phase 208-volt $^{1}/_{75}$-horsepower 1,800-rpm synchronous motor at a speed of one revolution per minute. This speed requires a ten-second interval to pass from one color into another, or into black-out, and was determined by test and experiment to be the most desirable for smooth blending.

The problem of keeping several drums operating in multiple and with color filters always in the same relative positions was solved by a magnetic braking system that brings all drums on any circuit to a quick stop—actually within $1^{1}/_{2}$ revolutions of the motor shaft. The power for braking is supplied by a separate 60-volt d-c source, and the motor circuit is so arranged that whenever motors are disconnected from their a-c power source, two phases of the motor instantly and automatically are short-circuited and connected to one side of the d-c circuit, the other side of the d-c braking circuit being at all times common with the third a-c phase wire. In addition to the d-c braking feature, all color drums on any circuit are arranged to be resynchronized automatically at the black-out position of the color drum. This feature requires the use of a small relay, together with a cam and limit switch for each motor.

The colors and their relative positions as actually selected for the mercury projector of each twin unit are: clear, light blue, dark blue, black-out plate, "surprise" pink, and black-out plate. For the incandescent source they are: clear, yellow, blue-green, black-out plate, red, orange. The 1,500-watt screen-grid incandescent lamp has a rated efficiency of about 25 lumens per watt, or a total output of 37,500 lumens. The 400-watt mercury capillary lamp has a rated efficiency of about 45 lumens per watt, or a total output of about 18,000 lumens. Because actual tests indicated as much as 65 per cent light absorption for a one-inch depth of the brackish water available for use in the Lagoon, underwater placement of the twin lighting units was abandoned, and each unit so placed as to project approximately six inches above normal water line. Thus the glass covers of these twin units are subjected not only to the battering of the heavy deluge of falling water, but also to severe heat stresses, particularly over the incandescent unit. The narrow-beam reflectors so concentrate and localize the light beam that temperatures as high as 425 degrees Fahrenheit have been measured on the surface of the glass covers of the boxes directly above the incandescent lamps. A solution to this problem finally was achieved through the use of specially tempered plate-glass panels having exceptionally high transmission efficiency for the infrared rays. Standard heat-treated glass was found to be satisfactory above the mercury lamps.

To produce a mist or "curtain" effect around the base of the entire fountain display, there is a continuous row of atomizing nozzles. Illumination of this mist curtain is accomplished by continuous strip lighting. These strips are made up with receptacles spaced six inches on center to accommodate some 1,800 of the new 100-watt R-40 reflector-type lamps divided into four color groups—clear, amber, green, and red. Each reflector lamp is set in a separate adjustable cylindrical sheet-metal housing (figure 23) and provided with a natural-colored glass roundel.

FOUNTAIN CONTROLS

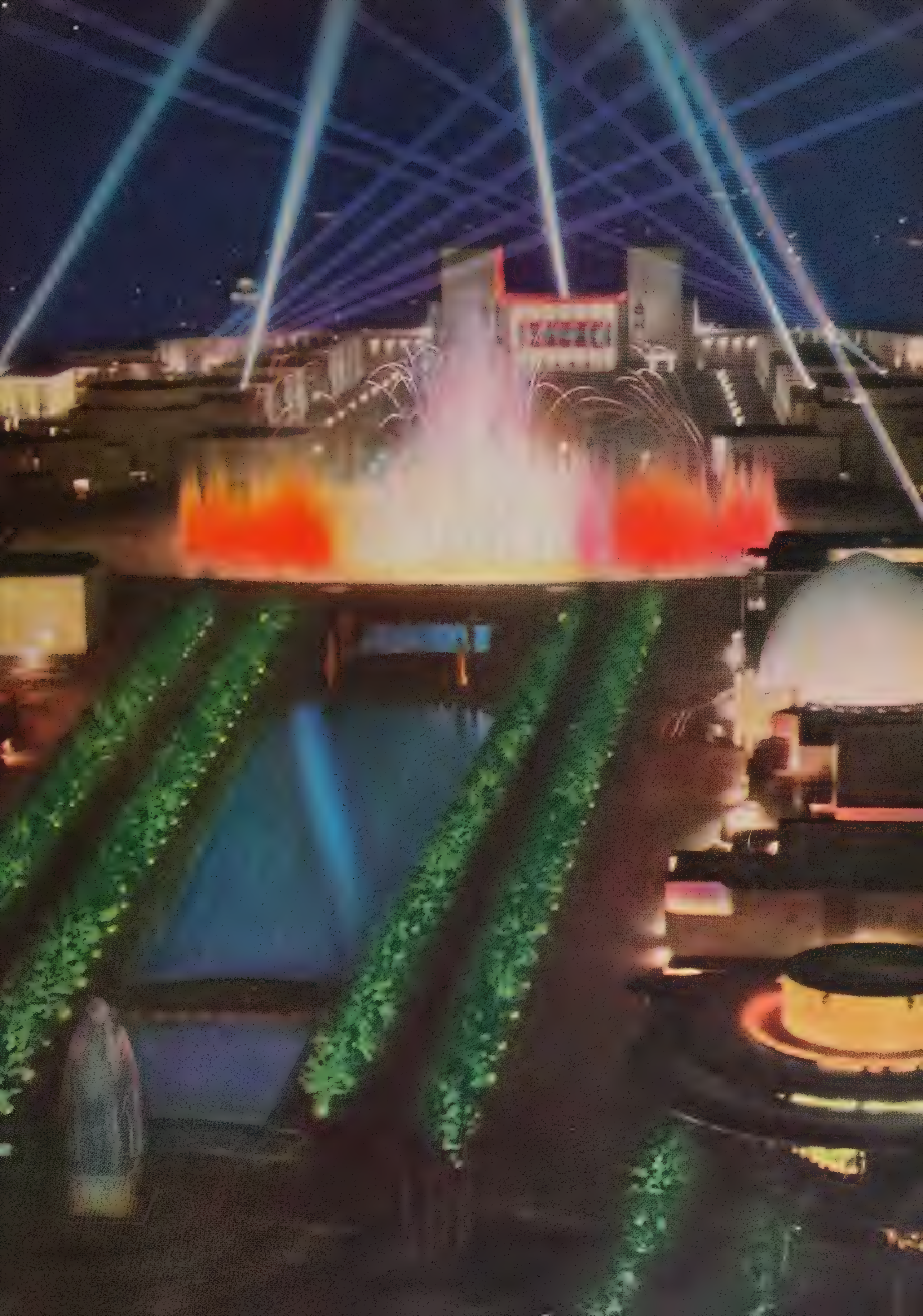
All elements of the Lagoon display—water, light, sound, flame, and fireworks—are remotely controlled from bench-type switchboards in a control room atop one of the government buildings overlooking the Lagoon (figures 24, 25). Water valves are selectively operated from small pilot switches which energize solenoid valves in the kiosks; these valves in turn admit city water to large hydraulically operated valves at the nozzles (figure 25). Water nozzles and associated twin-unit light projectors are placed to enable the formation of a variety of fountain patterns.

Control of the twin-light projectors is accomplished through contactor panels in the kiosks that in turn are operated from the control room. Lighting controls correspond to the water controls, so that groups of lights may be operated selectively with their associated water nozzles in a wide variety of patterns. In all, there are 19 main lighting-group controls (figure 24). Color control of these projectors is accomplished through close and accurate control of the synchronous motors driving the color drums.

The different switches on the panels in the control room permit independent operation of either mercury or incandescent color drums, facilitating ready combination of a wide variety of color tones. The grouping of a number of drums on one color switch (as many as 63 per switch) reduces to 19 the number of pairs of color-selection controls actually required for the 552 twin units on the Lagoon platform. An ingenious circuit arrangement permits the drum-control switches to be preset to any color, and then operated either individually or from master switches at the desired moment. An outstanding result of this method of color control is the subtle, almost imperceptible, transition from one color to another—an effect aided materially by the previously mentioned experimental selection of the optimum (ten-second) interval for a color translation.

Plate I (facing page). Constitution Mall, scenic backbo of the exhibit area, presents a picture of rare beauty at nigh This view, looking east from high in the Trylon during th evening fountain show in the Lagoon of Nations, shows ho the various effects are combined into one spectacular displa note also subdued illumination near the Theme Pla (foreground)

Courtesy Westingho



Courtesy Westinghouse

Plate II. Fluorescent trees themselves serve as the source of soft, evenly distributed illumination for the broad promenades along either side of Constitution Mall as well as around the Theme Plaza (figures 13, 19). Small illuminated jets frame the central reflecting pools (figures 13, 17)

Plate III. Pencil-like searchlight beams etch the night sky forming a canopy over the Court of Peace. Typical of plaza areas, the court is illuminated only by light from adjacent building façades, supplemented by a peripheral row of decorative street lights (C, figure 68)

Courtesy Westinghouse

Courtesy Westinghouse

Plate IV. Unprecedented in magnitude was the problem of evenly illuminating the three-acre exterior of the Perisphere. Special projectors mounted on adjacent rooftops provide any of three colors (amber, red, or blue) and project clouds drifting realistically across its surface (figures 2–5)

Plate V. The 800-foot Lagoon of Nations, Constitution Mall, and the Theme Center dominate this view looking west from the roof of the Federal Building which encompasses a large portion of the exhibit area. Brightly lighted pylons and other accents add sparkle to the scene

Courtesy Westinghouse

Courtesy Westinghouse

Plate VI. Decorative pylons representing man's first-known elements (earth, fire, water, air) form the southern terminus of the Court of Power (figures 37, 39). Floodlighted building façades constitute the principal source of illumination for streets and walkways

Plate VII. Clustered around the Plaza of Light south of the Court of Power are several electrical-industries exhibit buildings. The small fountain in the foreground illustrates how centers of interest are provided in small plazas and courts throughout the grounds

Courtesy Westinghouse

Corresponding to the 19 main lighting-group controls already mentioned, there are 19 panels in the central control board (figure 24). One of the dials on each panel controls the mercury units, and the other controls the incandescent units, throughout the corresponding group of twin-projector units associated with that panel. Each control dial is so arranged that it may be rotated in either a forward or a reverse direction to any preselected color position. The arrangement of circuits and associated relay and other equipment is such that the associated group of color drums will rotate correspondingly to the selected color position. At the same time, the motor-driven pointer on the control panel immediately behind each dial accurately follows and at all times shows the position of the associated color drums. This motor-driven indicator is a duplicate of the motor, limit switch, and cam arrangement that is associated with each color drum inside the twin units on the fountain platform, and the circuits provide identical d-c braking and synchronizing control.

Control of the striplights for the border curtain of illuminated mist is accomplished through the medium of motor-driven variable autotransformers located in the kiosks, but operated from the central electrical control board. All gas burners are electrically operated from the control room and are ignited by a small pilot flame which is kept burning, in spite of the deluge of falling water, by a 10,000-volt spark ignition system. Some 280 fireworks mortars are controlled electrically through connections to central patching-panel boards in the kiosks. A total of 50 firing positions is available at jack outlets above the mortar jacks, and jumpers permit any mortar or combination of mortars to be plugged into any firing position. A step-by-step relay energizes one after another of the firing jacks in response to the closing of the "fire" button on one of the main control panels in the control room.

In a separate pump room (figure 26) convenient to both the Lagoon and the control room are motor-driven centrifugal pumps totaling some 2,700 horsepower and capable of furnishing approximately 100,000 gallons per minute. Arranged to comprise an operating exhibit in themselves, these pumps supply the Lagoon fountains. Pumps and associated equipment lend themselves to a flexibility of control (figure 25) and a promptness of response that adds to the effectiveness of the fountain "shows."

Power for the lights and equipment located on the submerged Lagoon platform is transmitted from the main distribution board near the pump room to the kiosks by 11 700,000-circular-mil three-phase feeders. All wiring in the Lagoon consists of ordinary rubber-covered conductors, with so-called watertight insulation. All conductors, including those of control circuits, are merely laid in the water and strapped to the deck of the submerged platform without any additional protection.

FOUNTAIN OPERATION

Once each evening, just at dark, a 15-minute prearranged "show" is presented in the Lagoon, combining the various elements appropriately to render an unusual form of composition that has proved to be an ever-popular attraction (plates I, VIII). The music, played by a 42-piece band in a studio in an exhibit building, is picked up stereophonically by two microphones, relayed by wire to the control room where it is amplified and monitored, and then transmitted over two separate channels to the loud-speakers in the four kiosks on the submerged fountain deck. Each diagonally opposite pair of kiosks is served by one of these channels, thus giving a two-point stereophonic effect along both axes of the Lagoon. Each kiosk contains four high-frequency and two low-frequency speaker units, totaling 500 watts in audio output capacity. This is one of the first large stereophonic installations. The sound system has a total audio output of 2,000 watts.

Split-second synchronization of the various elements during the 15-minute nightly "shows" is accomplished with the aid of specially developed "cueing" machines, one located at the top of each of the triple-unit central control boards (figure 25) and one located in the music studio. These ingenious machines are in effect special adaptations of the machinery of curve-drawing electrical measuring instruments, with the curve-drawing elements removed. Basically, each machine consists of a synchronous-motor-driven mechanism that draws the cue sheet at 60 inches per minute under a wire marker which indicates the cue instant. Each cue sheet consists of a roll of graph paper, marked off in two-second intervals, on which are plotted against the time axis all the cues and special instructions necessary for the particular group of operators served by the particular cue machine. The several operators translate the cues into the actual operation of the various control switches, including the firing of the fireworks mortars. All "cueing" machines are started and stopped simultaneously by a master switch in the central control room. By means of this system, all operations are accomplished within a fraction of a second of the predetermined time schedule and the productions have been kept so uniform that their accuracy has become a byword.

Some of the same general type of equipment is used in Fountain Lake where a spectacular element appropriate to the amusement area is furnished by the mammoth fireworks display that follows the nightly Lagoon show. The feature of this display is its mobility. Pumps, light projectors, fireworks mortars, and all such equipment are distributed among several barges which may be shifted to provide different effects, subject to control from shore through equipment similar to that used for the Lagoon.

Court of Peace

The searchlight canopy over the Court of Peace constitutes the third and easternmost portion of the feature lighting spectacle of the Fair that begins at the Theme Center (plates I, III, V). This canopy of searchlight beams gives a third dimension to this part of the nighttime picture, producing the visual impression of a raftered or coffered ceiling over this whole 450- by 900-foot area, which is flanked on either side by the pavilions of foreign governments and dominated at its easterly terminus by the $3,000,000 United States Government Building.

VIII (facing page). The nightly fountain "shows" in agoon of Nations ingeniously combine the elements of jets, light, color, flame, fireworks, and sound into one onious whole. Part of the spectacle are the thousands itors who nightly jam every vantage point for this wholly ual and enormous display Courtesy Westinghouse

FIG. 20

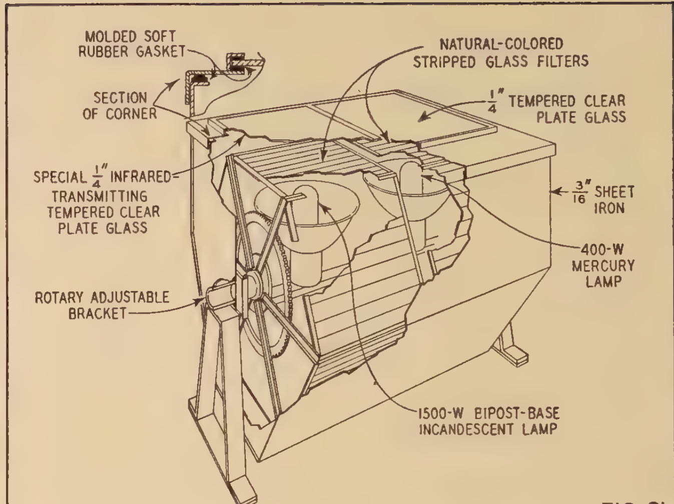


FIG. 21

FIG. 22

Figures 21, 22. Twin-unit semisubmersible projectors illuminate each main jet of the fountain. Both lamps are burned at full brilliance, color changes and dimming being accomplished by six-sided color drums with selected filters mounted in their sides, which are rotated around the lamp and reflector units

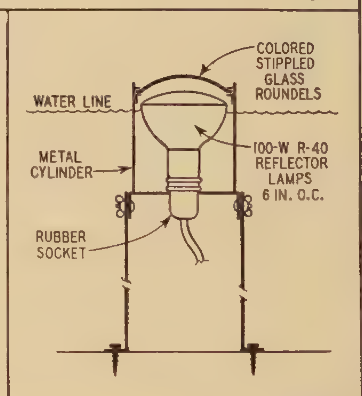


FIG. 23

Figure 20. The maze of water nozzles, lighting units, gas burners, fireworks mortars, and associated fountain equipment in the Lagoon of Nations is strikingly illustrated in this view which shows workmen preparing some of the equipment for the winter layover

Figure 23. Some 1,800 of these reflector-lamp units illuminate the spray from the continuous row of atomizer nozzles around the outer border of the fountain (27, 28)

Figures 24, 25. Twin control units (24) provide complete control over the twin-unit projectors (21, 22). A separate board (25) controls the water and gas-flame jets. Co-ordinated control of the various elements of the fountain display is achieved by several synchronized cue machines (25, top)

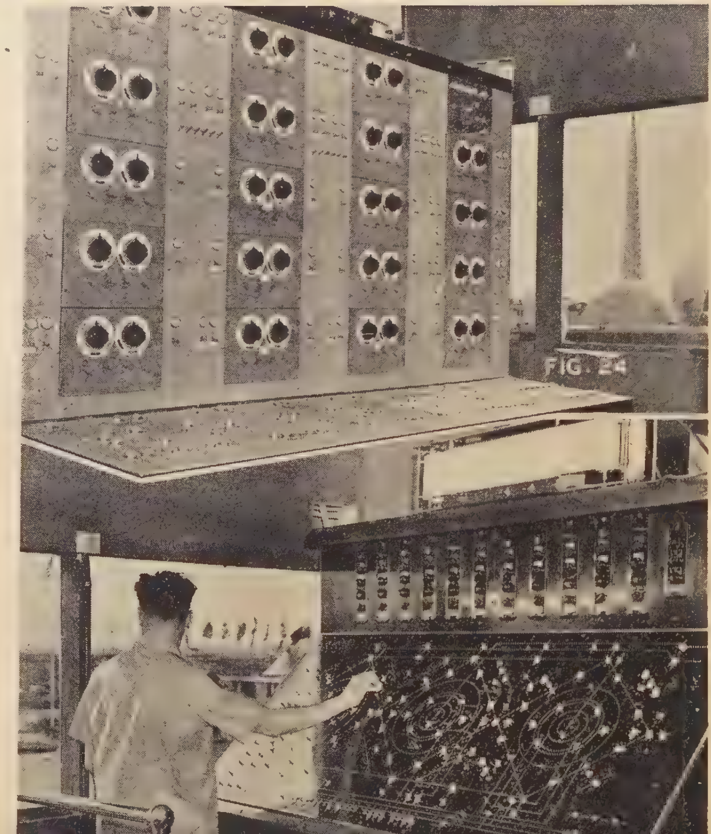


FIG. 24

Figure 26. A circular pump room, near one end of the Lagoon, itself a display feature with its 2,700 horsepower in 11 motor-driven centrifugal pumps, supplies a maximum of

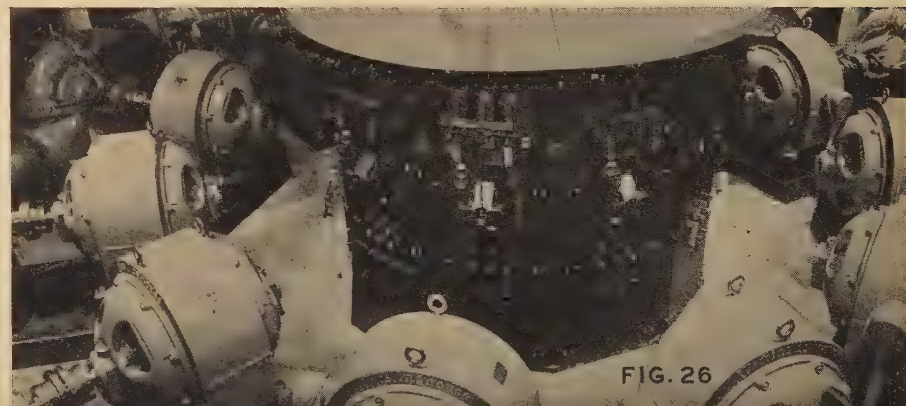


FIG. 26

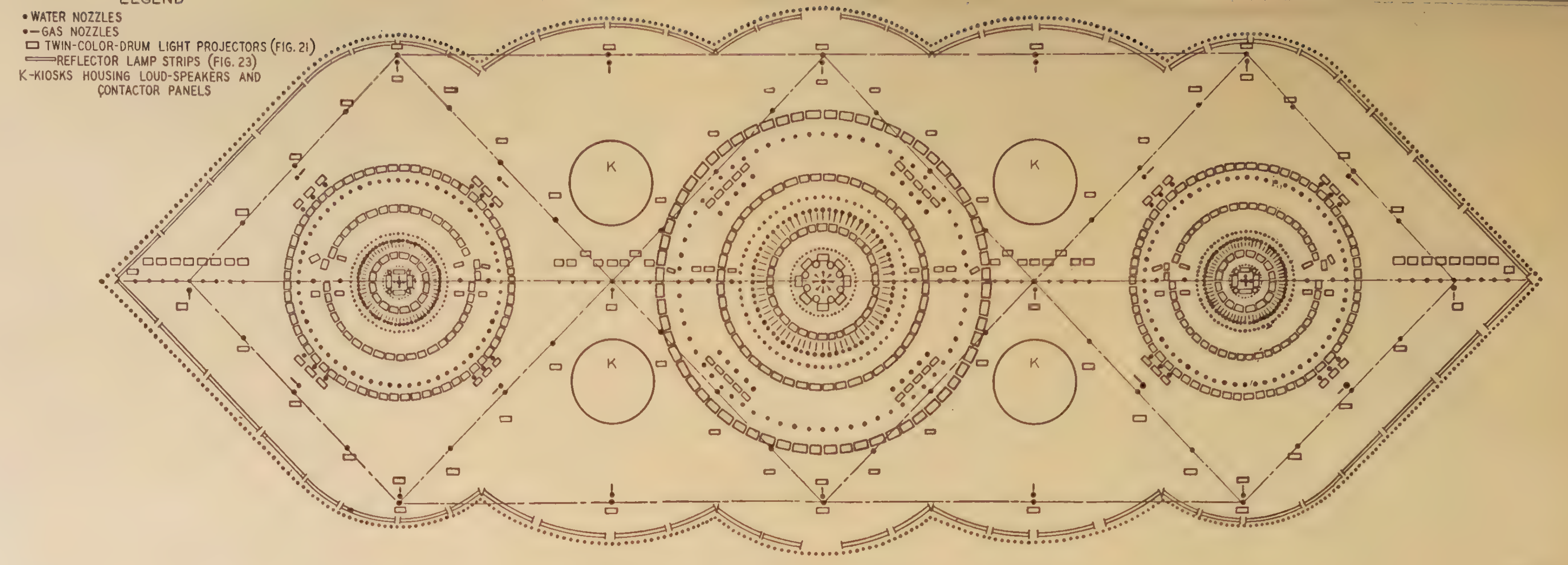


FIG. 27

Figures 27, 28. The major equipment on the 200- by 400-foot operating platform of the fountain in the Lagoon of Nations is arranged in three concentric rings (27, 28). Other equipment is so placed that various geometrical configurations may be achieved, as indicated by the dashed lines (27). The maze of equipment (20) includes 552 main water jets, each with its associated twin-unit lighting projector (21, 22), some 133 gas jets, and 285 fireworks mortars strategically arranged in eight operating groups. A continuous row of atomizer nozzles with associated lighting units (23) forms the outer border of the fountain. The total connected load for the Lagoon spectacle alone is 3,700 kw

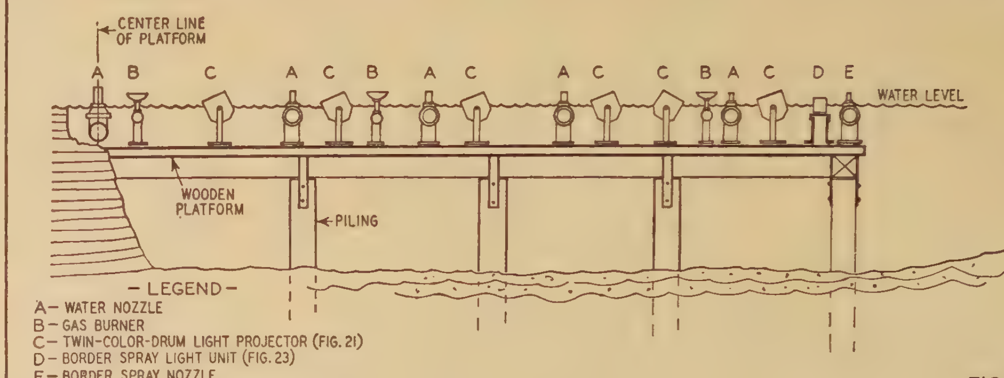


FIG. 29

Figure 29. This sectional elevation along the radius of one of the three operating circles of the fountain shows the relative placement of major equipment on the Lagoon deck and approximate operating water level

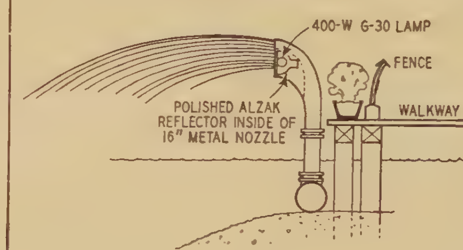


FIG. 30

Figure 30. Seven of these illuminated "megaphone" water nozzles at about 50-foot intervals around each end of the Lagoon surrounding the fountain provide animation in these areas

Oriented and designed to climax the vista down Constitution Mall from the Theme Center, the searchlight canopy is keyed to a pyramidal structure comprising five main searchlight beams which are directed to intersect at a point some 400 feet directly above the center of the Lagoon of Nations and which form an outer framework for the fountain display. Four of these searchlights are mounted on the tops of convenient buildings at the four points of the compass at distances averaging some 700 feet from the center of the Lagoon (plate I). Each of these four units is a 36-inch 125-ampere high-intensity automatic-feed carbon-arc projector. The fifth and most powerful searchlight beam comes from a similar 60-inch army-type searchlight mounted on the roof of the Federal Building exactly on a continuation of the center axis of the Mall. Intersecting this latter "ridge pole" beam of the canopy of light structure are two groups of eight parallel pencils of light from projectors mounted on the roofs of the foreign-government pavilions flanking the Court of Peace (plate III). Each of these 16 beams has as its source one of the newly developed 1,000-watt water-cooled mercury capillary lamps mounted in a suitable searchlight housing (figure 31). The small size of the actual source of this light (approximately 1.5 by 25 millimeters) is ideal for the purpose, producing a narrow "pencil" of light.

Within the limits of this article it has been possible only to outline the plan and purposes underlying the lighting scheme of the New York World's Fair of 1939; to describe in some detail the most prominent lighting displays, and show how they have been accomplished; and to mention the significant new forms of lighting developed. Throughout the enormous exhibit area are numerous other interesting and novel lighting creations, unmentioned only because of space limitations. Most of the significant basic forms of lighting, however, are represented among the various illustrations and application sketches, although, of course, many different variations, combinations, and adaptations were used by different exhibitors, all of whom made effective use of new and attractive lighting arrangements.

A World's Fair, by its very nature, offers exceptional opportunities for the presentation of new ideas. The keynote of the New York World's Fair is "better living in the world of tomorrow." Especially in the field of illumination has this keynote successfully and significantly been carried out. The Fair served as a stimulant to creative minds seeking departures from the conventional; also as a proving ground for new and better light sources, for improved methods, systems, and techniques. Its success is evidenced by such developments as the rapid commercial acceptance of the low-voltage fluorescent lamp, and the increased consciousness of lighting as an element of architectural design, a foretaste of the practices of tomorrow.

The author is indebted to many individuals and companies for helpful co-operation in the course of his work at the New York World's Fair. The Westinghouse, General Electric, and Eastman Kodak companies all went out of their way to place their facilities at the disposal of the Fair for carrying through many of the new developments. The Westinghouse company's Lighting Division gave every assistance in the final design and manufacture of most of the special lighting equipment used in the Lagoon of Nations, the Court of Peace, and at the Theme Center; the General Electric Company expedited the development of the low-voltage fluorescent tubes and related equipment; the Eastman Kodak Company designed and manufactured the significant new motion-picture projector for the Theme Building.

Special acknowledgment for valued and comprehensive co-operation is made to Edward H. Sniffin and H. M. Hays of the Westinghouse company; also to W. F. White and Irving Yost of that company for their untiring assistance. C. M. Cutler of General Electric acted very effectively throughout the construction period as liaison engineer between the Fair and the laboratories and plants of his own company. Fordyce Tuttle, of the Eastman company, in addition to his work in the development of the special Perisphere motion-picture projector, contributed much to the solution of other important optical and projection problems. The author's indebtedness is acknowledged to John H. Kliegl for the development of special-effect projection equipment; to Daniel Rollins of the Ward-Leonard Electric Company for the design and manufacture of control equipment; to D. D. Gillespie for the manufacture of the intricate control boards for the Lagoon of Nations display and the Perisphere Theme Show; also to A. B. McKenna of the Westinghouse Lamp Company and to Albert Fuller of the Eastman Kodak Company. The author expresses special appreciation to Editor G. Ross Henninger of the AIEE and his staff for their helpfulness in the preparation of this article.

Editor's Note: Incidental to the preparation and publication of this article, persons and organizations too numerous to mention have made valuable contributions which are acknowledged hereby. Special credits are due as follows: To P. L. Giering, J. G. Lawrence, and other members of the World's Fair staff, especially Wm. W. Morris who carried his camera 300 feet up into the Trylon to secure the view shown on plate I; to Harry Flowers, of the Flowers Photo Engraving Corporation, New York, for valuable assistance in the preparation of the color plates; to the Westinghouse company for making these plates available for use in Electrical Engineering; *to the General Electric Company, the General Motors Corporation, the Westinghouse company, and the World's Fair Corporation for various illustrations.*

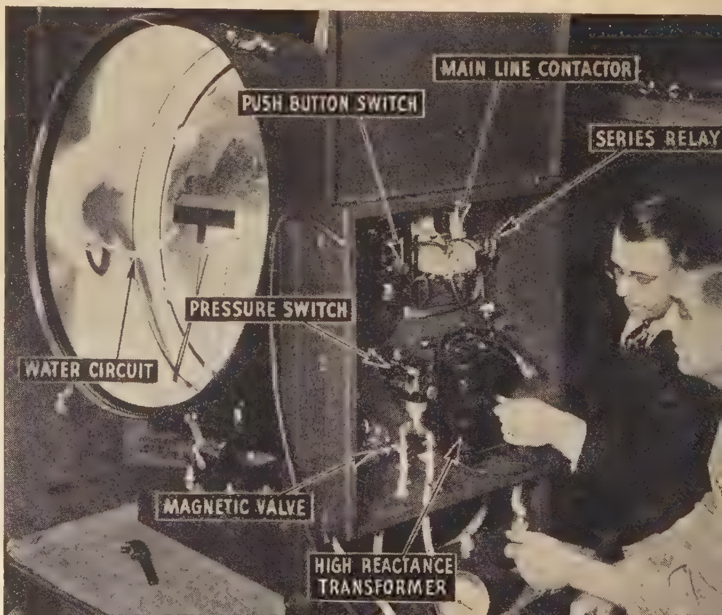


Figure 31. The 16 pencil-like searchlight beams forming a canopy over the Court of Peace (plate III) have as their source the newly developed 1,000-watt water-cooled mercury capillary lamp. One of the searchlights with associated control equipment is shown here

This lamp operates at 840 volts and produces some 65,000 lumens, an equivalent brightness of about 300 candle power per square millimeter, which is about one-fifth the brightness of the sun. About three quarts of cooling water per minute is required for each lamp

Some Pylons

Decorative pylons, strikingly illuminated at night, provide sharp accents that contribute sparkle to the nighttime scene, at the same time serving as points of orientation for New York World's Fair visitors

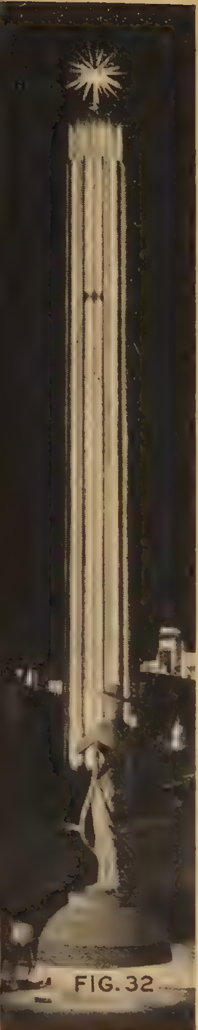


FIG. 32

FIG. 34

Figures 34, 35. Two pairs of 66-foot pylons at the west entrances are brightly outlined at night by high-voltage fluorescent tubing hidden in reflecting coves (35). The circular panels at the top are illuminated by incandescent lamps

FIG. 36

Figure 36. The serpentine tracery of these 145-foot "hairpin" pylons is provided by exposed pink and green high-voltage fluorescent tubing

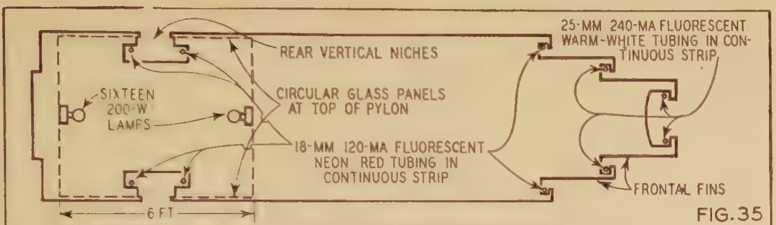


FIG. 35

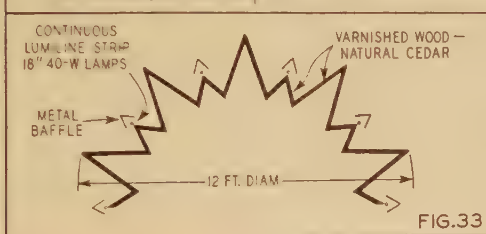


FIG. 33

Figures 32, 33. An effective illusion of translucence is given to the varnished natural cedar surface of the 115-foot Star Pylon by continuous Lumiline strips hidden behind reflecting troughs

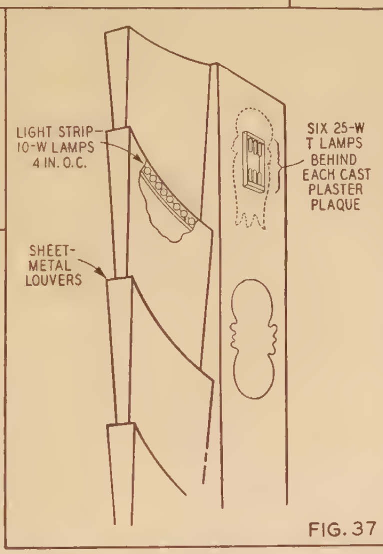


FIG. 37

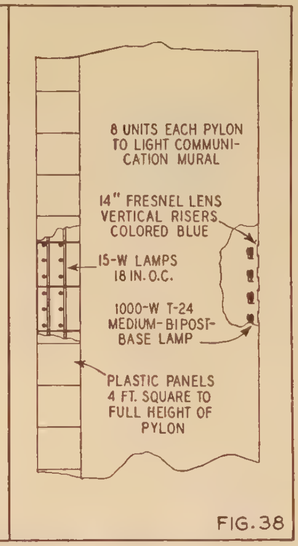


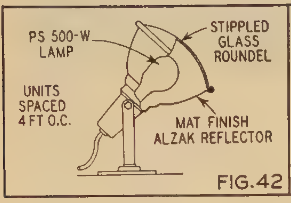
FIG. 38

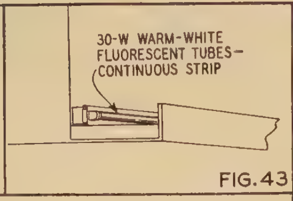
Figures 37–40. At opposite sides of the Theme Center: Four 55-foot louvered pylons (37, 39) representing earth, air, water, and fire, man's first-known elements, mark the southern terminus of the Court of Power; two 116-foot pylons stand in front of the building at the north end of the Court of Communications (38, 40). Incandescent projectors in the backs of the latter illuminate the mural

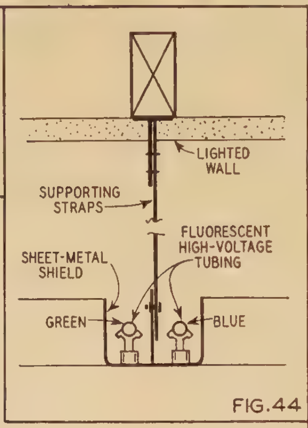
FIG. 40

Typical Exteriors

IN general the design of each Fair exhibit building provides a single dominating architectural element such as the spiral pylon on the Operations Building (figure 48). These elements serve to individualize the buildings and in most instances are the primary source of "sparkle" lighting for the structure itself. Thus the lighting treatment for individual buildings is developed to meet the special needs of those buildings, as in all decorative pylons (figures 32–40), and utilizes a wide variety of light sources including high- and low-voltage fluorescent tubing, much of which is used exposed (figures 45, 53). In some instances where a particular translucent effect is desired, tubing of different colors is concealed as in the fin of the Chemicals and Plastics Building (figures 41, 44). The façades of the structures in general are treated







Figures 41–44. Conventional floodlights (42) illuminate the upper facade of the Chemicals and Plastics Building (41). Fluorescent cove lights (43) are used underneath the canopy, while a new type of downlight (59) is installed in the canopy ceiling. The plaster wall of the fin at the right is given a translucent appearance by high-voltage fluorescent tubing concealed under a metal grid set out from the wall (44)

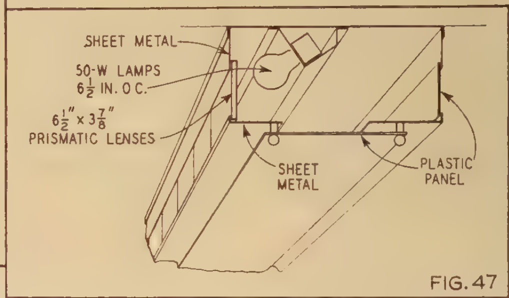
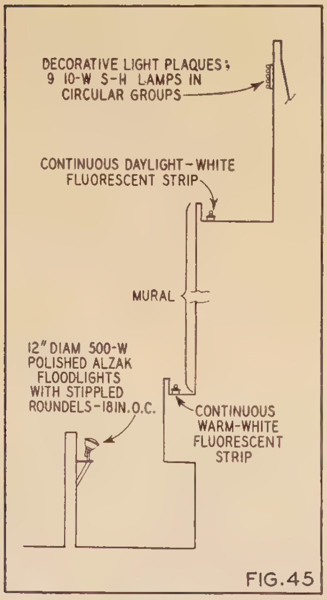


Figure 47. Details of lighting strip under entrance portico of Operations Building (48)



Figures 45, 46. The lighting of the huge mural on the North Foods Building illustrates effectively the use of reflector strip lights combined with floodlighting. The brilliant reds of the mural are emphasized by the use of pink glass roundels. Continuous strips of low-voltage fluorescent tubes illuminate the setbacks, and the top is crowned by a ring of circular nine-lamp plaques. Triple zigzag strips of fluorescent neon tubing encircle the building near the top, except for the area shown

Figure 48. The spiral pylon of the Operations Building is composed of 12-inch 40-watt T-8 lamps on four-inch centers mounted in a spiral trough supported by a central pipe. The facade at the left is lighted by blue fluorescent tubes in fluted coves. A decorative strip (47) underneath the portico illuminates mural and walkway

with built-in lighting units; these serve to illuminate the painted wall murals which in turn reflect soft diffused light to adjacent walkways. The colors of light sources are selected to accentuate the colors of the murals or façades, and in some instances additional color filters are applied. The use of plaques, as on the Hall of Communications (figures 50, 51), provides many possibilities for accent color lighting applicable to both decorative and utilitarian purposes. On this and the facing page are presented selected night views showing typical exterior lighting. Space limitations obviously permit illustrating only a few typical applications of the significant types of exterior illumination at the Fair.

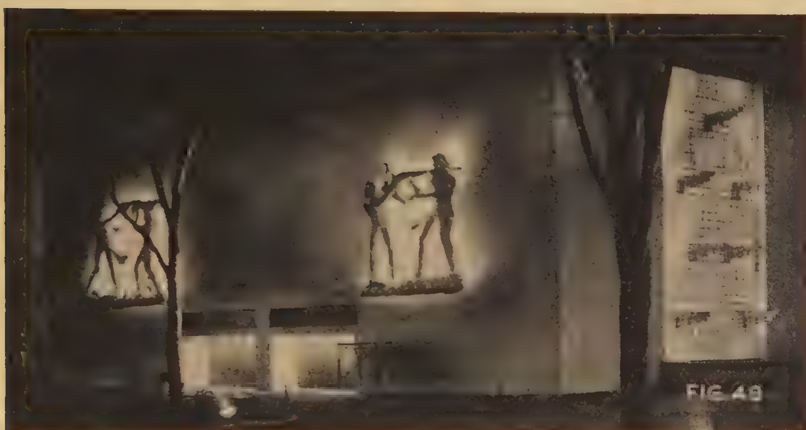


Figure 52. At the entrance to the Shelter Building are two rows of 150-watt units with prismatic lenses; the inner row is directed toward the mural, difficult to light because of its specular surface, and the outer row downward

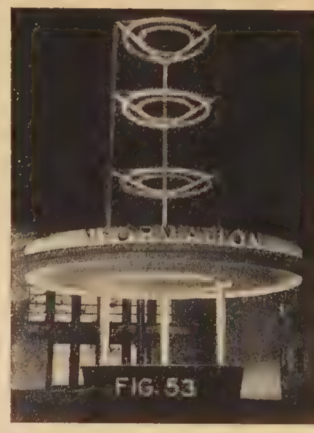
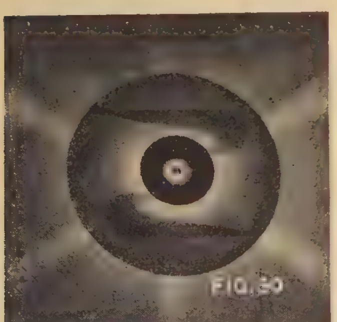
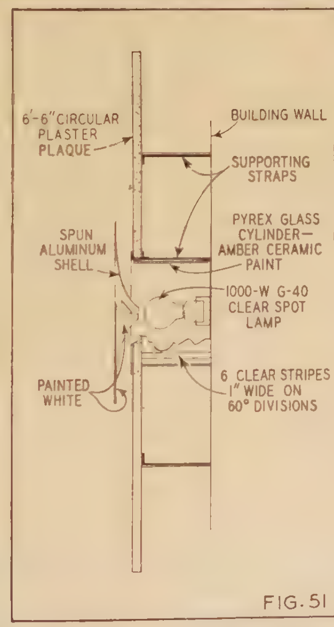
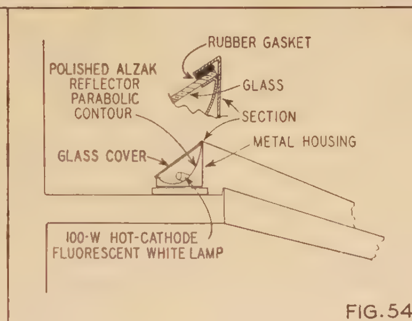


Figure 53. Exposed fluorescent tubing illuminates this typical information booth

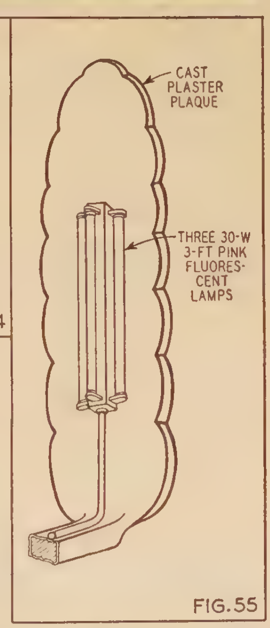
Figure 49. Back-lighted sculptures and blue and white fluorescent tubes behind a glass-brick wall provide decorative elements and unobtrusive walkway illumination near the Theme Center where special precautions are taken to avoid diluting the Perisphere illumination. The figures are approximately 18 feet high







Figures 54–56. Floodlights employing the new hot-cathode fluorescent lamp preserve the natural beauty of the blue, green, and white murals (54, 56) along the east side of the Court of Power. Decorative plaques between murals are back-lighted by groups of fluorescent tubes (55, 56). Note flower-like street lights (1, 68)



Figures 50, 51. Back-lighted plaster plaques provide general illumination and decoration along the west wall of the Hall of Communications. Other plaques of different design serve a similar purpose along the east wall

FIG. 57

FIG. 62

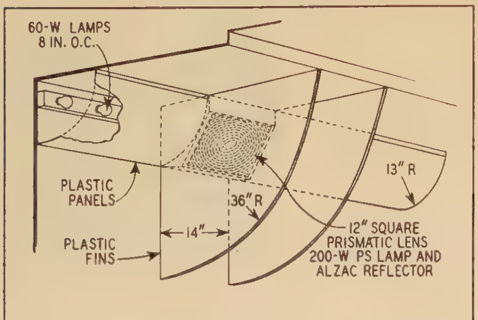


FIG. 58

Figures 57, 58; 62, 63. The main exhibit hall of the Chemicals and Plastics Building appropriately utilizes plastic panels and fins, combined with prismatic lenses, in a decorative strip extending all around the outer edge of the ceiling (57); incandescent lamps in strips and in reflectors provide the illumination (58). The exhibit wing of this building (62) is illuminated by a central row of units using low-voltage fluorescent tubes and semicircular plastic fins (63). The use of new light sources and new materials is typical of general illumination applications throughout the Fair

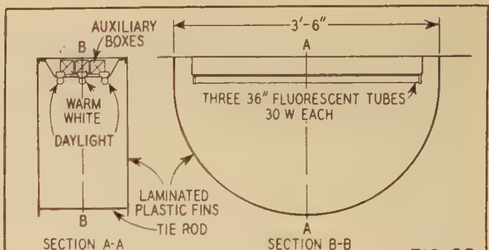


FIG. 63

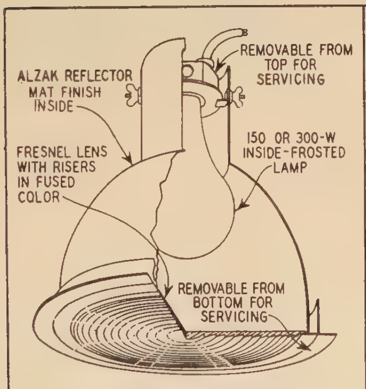


FIG. 59

Figure 59. New downlight ceiling fixture used extensively throughout the Fair (61)

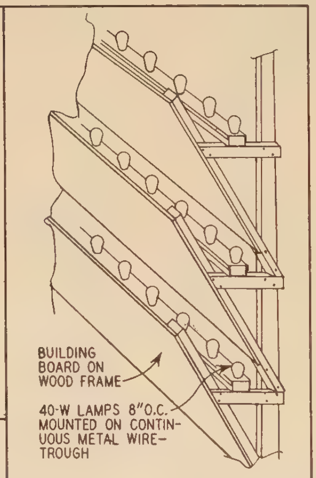


FIG. 60

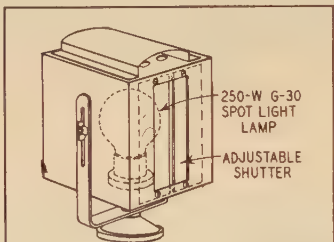


FIG. 64

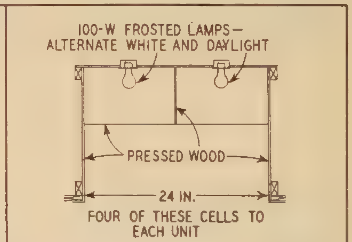


FIG. 65

Figures 60, 61. Indirect illumination in this exhibit wing of the Hall of Communications (61) is provided by continuous incandescent strips concealed behind the louvered upper wall surfaces (60)

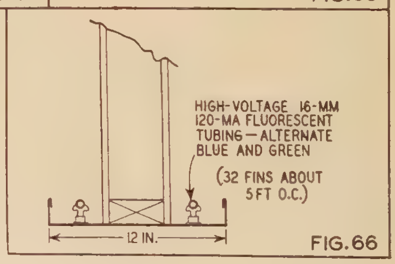


FIG. 66

FIG. 61

Figures 64–67. North Foods Building has been cited for its effective coordination of light and architecture (67); 32 projectors (64) hidden above the ceiling plaque throw light beams toward the huge fins, which are lighted by fluorescent tubing (66). Ceiling wells (65) illuminate the exhibit wing

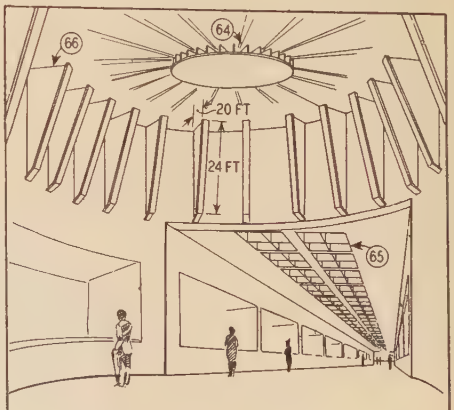
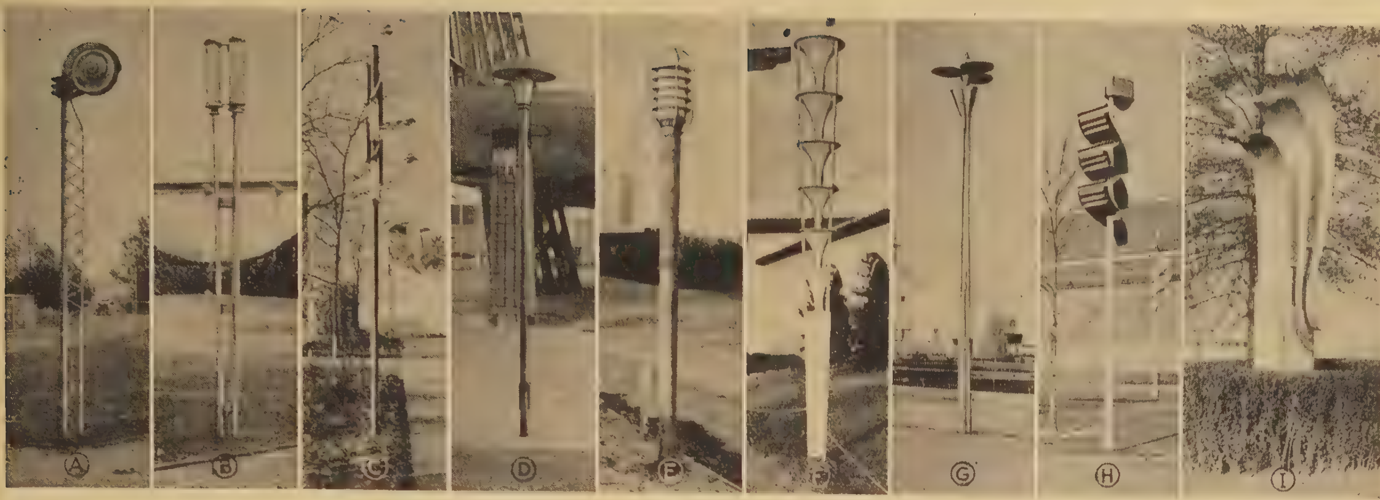
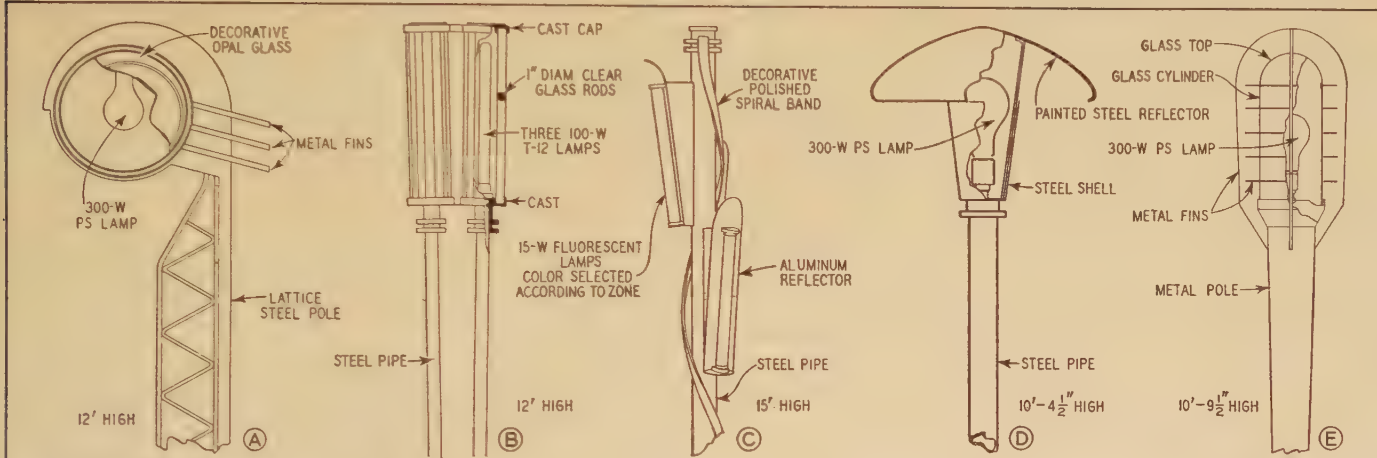


FIG. 67

Typical Street Lights





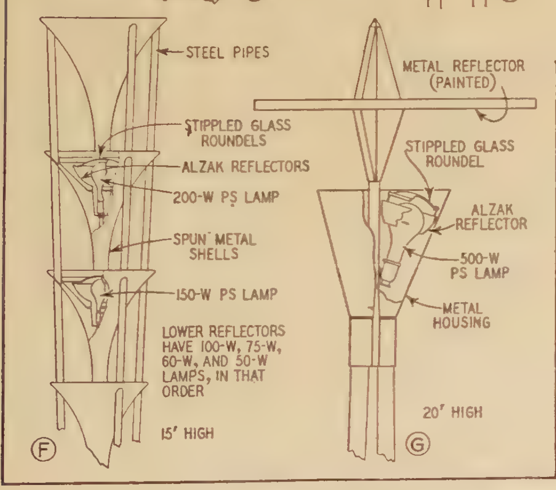


Figure 68. Principal lighting for streets and walkways is provided by the illuminated facades of buildings, but in some areas additional illumination is required. Nine of the unusual street lighting luminaires developed to meet this need are illustrated here, together with diagrams showing types and application of light sources

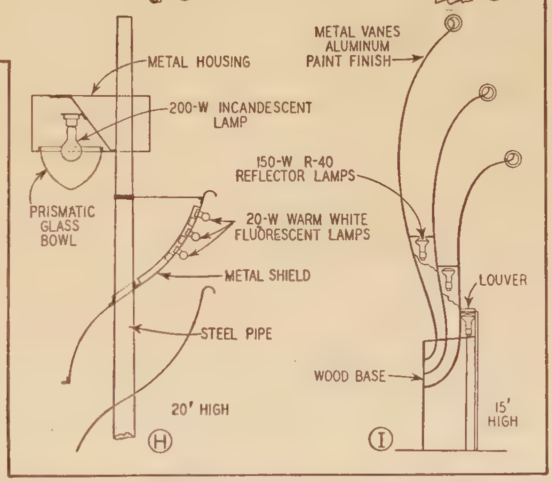
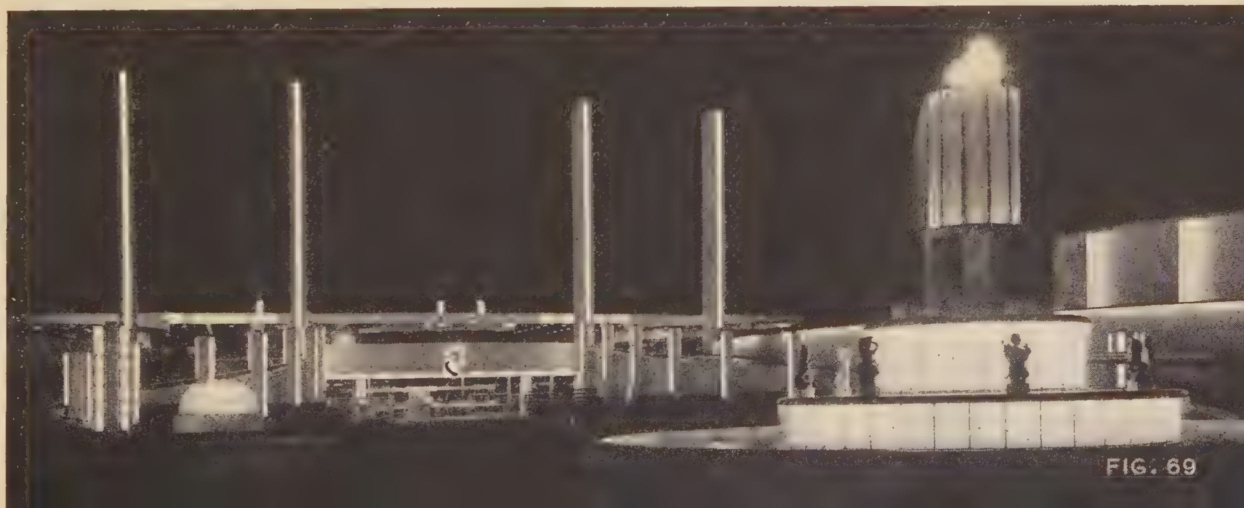


Figure 69. This fountain in Bowling Green plaza, which utilizes back - lighted glass blocks topped by a gas flame, effectively illustrates the general treatment of small courts and plazas throughout the Fair grounds by providing so-called "accents" in these areas



Power-Supply and Public-Address Systems at the New York Fair

P. L. GIERING
MEMBER AIEE

JOHN G. LAWRENCE
NONMEMBER AIEE

An 80,000-kva electric distribution system supplies the Fair's light and power loads; an extensive public-address system broadcasts programs and announcements throughout the Fair grounds.

TO SUPPLY the light and power load at the New York World's Fair two 40,000-kva 27/4-kv substations and some 278 4,000/120–208-volt primary service centers are provided. To prevent a service failure involving either substation from crippling operations too seriously, independent radial distribution systems from each of the substations pretty well blanket the entire Fair grounds, with the total load of any one area pretty well divided between the two. This is probably the largest application to date of nonmetallic-sheathed cable on 4,000-volt service.

Carrying out the idea of segregation, the two main substations are situated on opposite sides of the exhibit area. Each contains four transformers of 10,000-kva capacity, each of which is directly connected to a separate 27-kv incoming feeder without intervening switching equipment. Each feeder is a three-conductor 500,000-circular-mil 29-kv lead-covered cable. On the low-voltage side, in each substation, the transformers are connected to a common bus through suitable voltage regulators and oil circuit breakers with relay protection for overload and reverse current. The main bus in each station may be cut into two sections through appropriate oil switches with differential relay protection, two transformers feeding each section. In general, from each bus section there are six feeder circuits and a spare (total 28 feeder positions for the two stations); each feeder is equipped with an oil circuit breaker and overload relay protection. The substations were built and are operated by the Fair corporation.

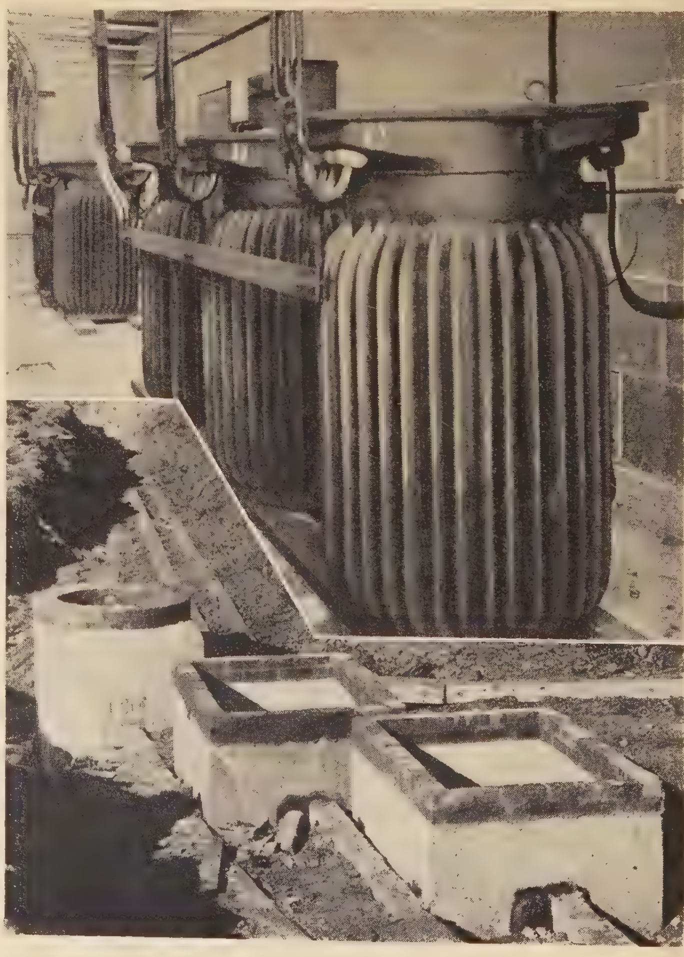
The 25 three-phase four-wire underground feeder circuits radiating from the two substations and serving the 278 primary service centers total about 50 circuit miles. These 4,000/120–208-volt service centers range from 10 to 2,000 kva in capacity, are strategically placed with reference to the building groups they serve and, in most instances, accommodate transformers independently connected to the two radial systems as already indicated. Transformers generally are located outside of buildings in roofless enclosures of which one or more building walls form parts; these enclosures harmonize with their related structures. Transformers are protected on the substation side by boric-acid fuses, of 25,000- or 40,000-ampere capacity depending upon the distance from the supply substation.

All buildings erected by the Fair corporation and all the larger exhibit buildings are served by two feeders, one from each substation, with the lighting load divided between them. Certain exhibit buildings fed from only one circuit, have storage batteries of ample capacity for emergency lighting. The 120–208-volt circuits inside the buildings are carried on racks in the attics adjacent to catwalks, from which the branch-circuit panels are also accessible. An overlap of illumination circuits is provided in all parts of the grounds to prevent complete darkness of any area in case of a substation failure. No provision is made at service centers for transfer of load from one distribution feeder to another.

Four-inch precast concrete feeder ducts are laid directly in the ground without any supporting mats. Similarly, precast concrete manholes are used. Separate, but adjacent, ducts and manholes are used for the feeder systems from the two substations.

Feeder cables are insulated with an oil-base ozone-resisting compound and covered with asbestos conducting braid; bare copper cable is used for the neutral conductor. From 500,000 circular mils for feeder cables and number

(Top) Typical primary service center with dual feeders, one from each substation, supplying independent transformer banks. (Bottom) Separate duct lines for power cables from the two substations and for telephone cables were laid in the same trenches, with separate manholes



P. L. GIERING is chief electrical engineer and JOHN G. LAWRENCE is superintendent of displays, New York World's Fair 1940 Inc.

4/0 for neutral, the sizes are diminished respectively to number 4/0 and number 2 toward the ends of the circuits where the load is less. Service connections have been materially simplified and facilitated through the use of preinsulated mechanical fittings called "crabs", where the cables are joined in the manholes. Groups of street lights, concession stands, and small exhibit buildings receive power at 120 or 208 volts from convenient transformer service centers associated with the larger buildings. For these circuits rubber-insulated nonmetallic-sheathed cables are used, buried directly in the earth with a plank covering to prevent mechanical damage. Under roadways the cables are in ducts.

All power and communication circuits to and throughout the Fair grounds are underground.

PUBLIC-ADDRESS SYSTEM

From 23 loud-speaker outlets at strategic points throughout the Fair grounds, special announcements, music, and other programs are broadcast by means of an extensive public-address system. The heart of this system is the public-address center in the Hall of Communications, which is constructed as an exhibit and is visible to the public through large plate-glass windows.

The public-address center contains a studio for the pickup of orchestras, a smaller studio for the origination of talks or interviews, and two small booth-type studios for the origination of programs consisting of transcriptions, announcements, or pickups from radio receivers. An additional function of the small studios is to provide final monitoring of programs transmitted to the public-address center from various parts of the Fair grounds.

All programs clear through a large horseshoe-shaped master console which forms the centerpiece of the master control room. The functions of this console are analogous to the master control console of a well-equipped radio-broadcasting station. Five panels on the face of this console perform four major functions. The program-selection panel contains the controls and indicators of an automatic preset relay system which permits the independent switching of any of six program-channel control units on the console to any of ten input lines feeding the console. The program-control panel contains six channel-control units, each of the "bridging" type, and provides individual means for amplification, level control, level indication, and monitoring. Each of four channels feeds a high-level low-impedance bus; the remaining two channels are used to feed Fair programs to various radio stations. Two program-distribution panels provide 50 individual outlet-control panels which feed telephone lines running to the various outlets around the Fair grounds. Each outlet panel provides for: switching the outlet to any of the four busses; volume control; monitoring connection; and remote switching of the a-c power at the loud-speaker outlet amplifier, which is accomplished by direct current over a telephone line. Completing the master control console is an order-wire panel which contains all equipment for the control and operation of six incoming telephone lines used for communication during remote pickups.

In general, each outlet consists of an amplifying system to bring the program up to the desired output level, and a loud-speaker system capable of handling that output. For the most part, the amplifiers are standard commercial units capable of an audio output of 50 watts each. Whenever necessary to supply more than 50 watts to a speaker system, two or more amplifier units are used in multiple.

Except for the Perisphere outlet, only three types of loud speakers are used throughout the grounds:

Type A. Self-contained two-way speaker system utilizing theater-type high- and low-frequency units. Speakers are housed in a weatherproof 36-inch cube and have an audio output of 50 watts.

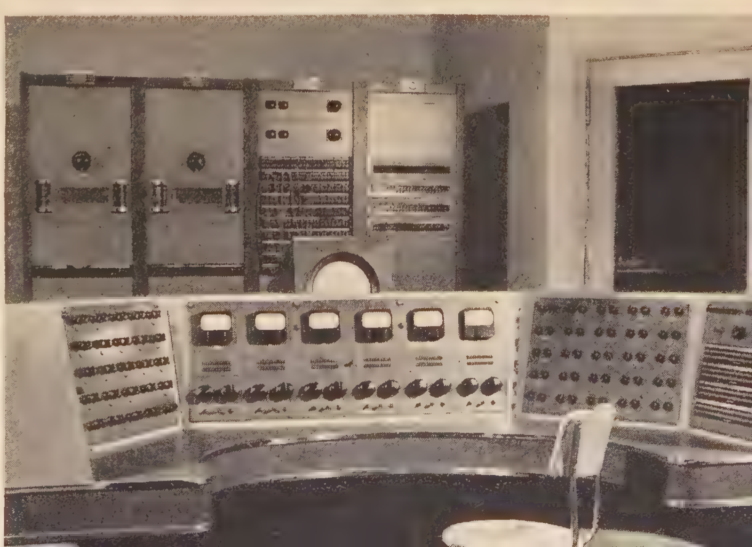
Type B. Eighteen-inch permanent-magnet speakers with waterproof diaphragms; audio output 25 watts. These units either use the surrounding wall surfaces for baffle area or are mounted in 56-inch spun aluminum bidirectional baffles.

Type C. Metal weatherproof exponential horn driven by a unit having a plastic diaphragm; audio output 100 watts (used in only one location).

In general, all speakers are concealed either by building them into existing wall surfaces and facing with inconspicuous grills, or by modeling them into specially designed towers.

The Perisphere unit is perhaps the most interesting of the 23 outlets. Here the under surface of the Perisphere and the surface of the pool of water beneath it are utilized as a circular "horn" of approximately exponential form capable of distributing sound around a 360-degree angle. The driving equipment is installed in a pit 22 feet in diameter and 12 feet deep below the exact center of the sphere; it comprises 24 low-frequency and 12 high-frequency units. An amplifying system having an audio output of 720 watts is used to drive the 36 speakers. The extraordinary low-frequency characteristics of this system permit a sound pressure level of $2^1/_2$ bars to be effected at the edge of the pool at a frequency of 20 cycles, which is said to establish this "horn" as the most powerful low-frequency reproducer ever constructed. Since the curb of the loudspeaker pit is only six inches above the water level of the pool, and no mechanical connection exists between the pit and the Perisphere, the system does not in any way mar the architectural lines of the structure.

All Fair programs, whether broadcast throughout the grounds from the 23 loud-speaker outlets or transmitted to radio stations for radiobroadcasting purposes, clear through this master control console at the public-address center in the Hall of Communications



Of Current Interest

From A E C • •

ITEMS appearing under this heading are from the news service of American Engineering Council.

SEC Moves to Enforce Holding Company Ban

Nine of the largest public-utility holding companies in the country, with assets totaling nearly $9,000,000,000, have been served by the Securities and Exchange Commission with orders directing each of them to submit plans for complying with the so-called "death sentence" provisions of the Public Utility Holding Company Act of 1935, designed to eliminate complicated intercorporate relationships. The companies concerned are: Electric Bond and Share Company, Engineers Public Service Company, Middle West Corporation, United Gas Improvement Company, Cities Service Power and Light Company, North American Company, United Light and Power Company, Standard Power and Light Corporation, Commonwealth and Southern Corporation.

The statute permits operating utility companies to be controlled by holding companies which are, in turn, controlled by other holding companies, but forbids this process to be carried any further. (At present some systems have as many as nine layers of corporate ownership.) It also limits a holding company to one integrated public-utility system located in the same geographical area plus such additional systems as meet certain requirements, including geographical proximity.

In the law as passed the SEC was directed to bring about the necessary simplification "as soon as practicable" after January 1, 1938. Sincet his date the commission has endeavored to induce the companies to act voluntarily, with some success. But the results have been so limited that it is now taking this means of bringing about an acceleration of the process.

First formal answer to the order was made recently by the Engineers Public Service Company. While acknowledging that its properties do not meet the standards of the Public Utility Holding Company Act of 1935, the company asked the commission to dismiss the pending proceedings on the ground that the "death sentence" contained in the act is unconstitutional. It contends that compliance with the law would force it, within two years, to divest itself of large blocks of securities and other assets in what would amount to a "forced liquidation," to the detriment of its stockholders. This, it argues, would be the equivalent of taking private property without just compensation, and is therefore contrary to the Constitution. The Engineers Public Service Company controls operating electric companies in 15 states.

Simplification of another big holding-company system—Associated Gas and Electric—is now in the hands of trustees following the bankruptcy of its two top organizations, Associated Gas and Electric Corporation and Associated Gas and Electric Company. Control over the former has been vested by a Federal court in Willard L. Thorp, research director for Dun and Bradstreet and a special adviser to Secretary of Commerce Harry L. Hopkins, and Denis J. Driscoll, chairman of the Pennsylvania Public Utility Commission and a former Congressman who took a leading part in passing the Holding Company Act. Affairs of the second company are in the hands of Walter H. Pollak, attorney. These two companies filed bankruptcy petitions following an order by the SEC forbidding what it considered unjustified "upstream" payments by companies in the system.

That the SEC is considering certain relaxations in its rules in order to remove obstacles from the issuance of corporate securities was disclosed by Chairman Jerome Frank in a recent speech. Specifically mentioned was a reduction in the number of public hearings now held before approving such issues by utility companies. Present practice is to schedule hearings in all cases, many of which, it is felt, could be eliminated.

George C. Mathews, who has served as a commissioner since the formation of SEC, resigned on April 15 to become associated with the Northern States Power Company.

FCC Faces Problems

The regulation of television broadcasts for commercial purposes and the provision of channels for the Armstrong system of frequency-modulation radio stations are providing current puzzles for the Federal Communications Commission, charged by law with responsibility for maintaining order in the radio spectrum.

On February 29, FCC issued an order stating that after September 1, 1940, television stations would be permitted to charge commercial sponsors with the cost of program production, hitherto carried on experimentally. On the strength of this order the Radio Corporation of America started a selling campaign on television receiving sets at prices ranging from $200 to $600, with the intent of marketing 25,000 sets this year. Two rival companies in the television field—Philco and Dumont—protested that the sale of a large number of RCA-type receivers would tend to "freeze" the technical standards of an art still in the process of development or alternatively rapidly make these sets obsolete, to the disadvantage of their purchasers. Thereupon the FCC, on March 22, decided to reconsider its earlier order and suspended its effectiveness pending the results of public hearings that started on April 8.

Hearings on a number of pending applications for permission to construct new radio-broadcasting stations on the frequency-modulation principle began March 25. Experiments with this new type of transmission have developed a number of claimed advantages over the normal type of power-modulated broadcasting, including the elimination of static, greater fidelity, less interference between stations, and greater range for low-power transmitters. Since it requires radically different transmitters and receivers, however, it could supplant present facilities only at the expense of replacing millions of dollars' worth of equipment. Its supporters are pleading for the allocation of enough wave-bands to permit service in certain selected urban areas.

TNEC Opens Hearings on Technologic Changes

On April 8 the Temporary National Economic Committee began a new series of hearings, expected to extend over a period of some three weeks, to develop information on the broad subject of technological change and its effect upon employment and production. Invited to testify were over 40 leaders of science, industry, and organized labor in the fields of automobile manufacture, steel, coal, railroads, textiles, communications, office appliances, agriculture, and vocational and consumers' education.

In announcing the hearing Senator Joseph C. O'Mahoney, chairman of the committee, pointed out: "Without modern technology, mass production would not be possible; it is technology which has enabled industry to organize into great concentrated units of production and distribution. Technology has created many new industries and has provided many new opportunities for labor, though at the same time it has unquestionably displaced many workers. The committee plans to study seriously the impact of technology in all its implications, what it means in terms of employment, of unused capital, of the effective organization of our nation's resources."

The chairman also made it clear that the committee entered its task with no preformed judgments, and that the hearings were not intended to express support for his recently introduced bill to provide a system of rewards and contributions for the greater utilization of labor in industrial production through the taxing of machines.

Last month the TNEC completed a series of hearings on the effects of various state regulations upon interstate commerce.

Other Societies •

Quarter Century of Engineering Foundation. A recent report of the Engineering Foundation points out that since its establishment in 1914 the organization has carried out 73 research projects involving expenditure of more than $3,000,000. Out-

Future Meetings of Other Societies

American Association for the Advancement of Science. Summer meeting, June 17–22, 1940, Seattle, Wash.

American Physical Society. 235th meeting, June 19–20, 1940, Seattle, Wash.

236th meeting, June 20–22, 1940, Pittsburgh, Pa.

American Society for Testing Materials. 43d annual meeting, June 24–28, 1940, Atlantic City, N. J.

American Society of Civil Engineers. Annual convention, July 24–26, 1940, Denver, Colo.

American Society of Heating and Ventilating Engineers. Semiannual meeting, June 17–19, 1940. Washington, D. C.

American Society of Mechanical Engineers. Semiannual meeting, June 17–21, 1940, Milwaukee, Wis.

American Society of Refrigerating Engineers. 27th spring meeting, June 9–11, 1940, Skytop, Pa.

Edison Electric Institute. Annual meeting, June 3–6, 1940, Atlantic City, N. J.

Institute of Radio Engineers. 15th annual convention, June 27–29, 1940, Boston, Mass.

National Electrical Manufacturers Association. May 14–17, 1940, Hot Springs, Va.

Society for the Promotion of Engineering Education. 48th annual meeting, June 24–28, 1940, University of California, Berkeley, Calif.

Society of Automotive Engineers. Summer meeting, June 9–14, 1940, White Sulphur Springs, W. Va.

standing projects have included a ten-year study of alloys of iron, work of a special committee on cotton-seed processing, an arch-dam investigation, and research in the fatigue of metals. Of electrical-engineering interest are projects on welding and dielectric absorption; studies of personnel and engineering education have also been made.

Mathematics Congress Cancelled. The International Congress of Mathematicians, scheduled to be held at Cambridge, Mass., September 4–12, 1940, under the auspices of the American Mathematical Society (*EE, April '39, p. 180*) has been cancelled because of the war in Europe, it was announced recently.

Industry

Bell Laboratories Demonstrate Stereophonic Recordings

A demonstration program of stereophonic recordings of "enhanced music" was presented by Bell Telephone Laboratories, Inc., at Carnegie Hall, New York, N. Y., April 10, 1940. Recordings of orchestra, organ, and choral music, oratorio, opera, and drama were included in the program. The records are made on motion-picture film.

Stereophonic reproduction of music, first demonstrated in 1933 by Bell Laboratories in collaboration with Doctor Leopold Stokowski, then conductor of the Philadelphia Symphonic Orchestra, used three sound-projection systems to transmit not only the full volume and tonal range of the original, but also an illusion of the locations and physical space occupied by the performers. At the first demonstration music was transmitted by telephone from Philadelphia to Washington, D. C., over three specially conditioned circuits, and after amplification projected by three loudspeakers. Tone and volume of the music were modified by means of electrical controls. In 1935 a stereophonic system was used to re-enforce music presented at an open-air concert directed by Doctor Stokowski in the Hollywood Bowl, Hollywood, Calif. With the development of stereophonic recording, original recordings of stereophonically reproduced music are reviewed by the conductors, who may make desired tonal and volume changes by means of the controls, and new stereophonic records are made of the performance as thus "enhanced."

N. E. Research Day. Fostering research as a method of filling idle factories, the New England Council, regional development organization, plans to observe May 17 as "Research Day." A committee of the council is in charge of plans, with subcommittees for each of the six New England states. W. H. Timbie (A'10, F'24) professor of electrical engineering and industrial practice, Massachusetts Institute of Technology, Cambridge, heads the Massachusetts subcommittee, and H. C. Rankin (A'25, M'34) laboratory engineer, New England Power Service Company, Providence, R. I., that for Rhode Island.

Lighting Booklets. An illustrated reference booklet on lighting and wiring, entitled "Your Home" has been issued by the Western Institute of Light and Vision, as the second in its series of bulletins. Material in the booklet was compiled by F. A. Hansen (M'31) director of the organization. A revised edition of the first bulletin, "Seeing," which was published in 1939, has been issued also. Copies of the bulletins may be secured from the Western Institute of Light and Vision, 3407 Lowry Road, Los Angeles, Calif., at 25 cents per single copy, prepaid; quantity prices on request.

Education

Summer Graduate Institute. Armour Institute of Technology, Chicago, Ill., is sponsoring a summer graduate institute in engineering and science, during June, July, and August, 1940. The institute, intended for engineers, industrialists, and educators, will consist of three four-week terms, and is divided into seven sections, one of which will be on electrical engineering and physics. The division into four-week terms is planned to enable employed engineers and others to carry on advanced study during their vacations. Courses will be presented by members of the Armour faculty and visiting professors.

Effective Speaking Course. The ten-week summer course in effective speaking, presented annually for ten years under the auspices of The American Society of Mechanical Engineers, will be given at the Engineering Societies Building, 29–35 West 39th Street, New York, N. Y., beginning June 27, 1940. Conducted by R. C. Scafe, the course includes the fundamentals of salesmanship and human relations. The fee is $12 for members of the engineering societies; $15 for nonmembers.

Letters to the Editor

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Electric Distribution Systems in Buildings

To the Editor:

L. W. Moxey is to be commended for his use of Kelvin's law in connection with electric conductors in buildings, as illustrated in figures 2 and 3 of his paper "Electric Distribution Systems in Buildings," Electrical Engineering, March 1940. In figure 3 he states that with an average load factor of $\frac{0.5\times 2{,}000}{8{,}760} = 0.14$ or 14 per cent, and with energy at two cents per kilowatt-hour, it pays to use heavy conductors—that is, it pays to design them for less than the allowable temperature rise. The advantages in longer life of insulation, better voltage regulation, and possibility of future increases in connected load are obvious. A similar conclusion was reached by the writer in "Resistance Loss and Conductor Size," examples 5 and 6, *General Electric Review*, November 1938, page 484.

Of course, there are many branch circuits in buildings in which the load factor for the conductors is less than 14 per cent, and such circuits should usually be designed according to the temperature rise of the conductors or the voltage drop. On the other hand, there are circuits, such as in hallways of office buildings, where the load factor is much higher than 14 per cent, and where the use of Kelvin's law is particularly to be recommended.

The computations for Kelvin's law can be greatly simplified for practical designing. For each class of service a recommended maximum current density for copper can be computed. Then all that the designer needs to watch is to see that the current density in conductors, chosen in the usual way, does not rise above the maximum, and if it does, to specify larger conductors. The progressively lower price per pound of

conductors as the size increases is easily brought into the computations and enhances the advantage of using larger conductors.

This method of computation may be applied to single-conductor underground cables which in some favorable conditions should be rated, in order to save money, at less than their usual current rating based on temperature rise. The method is applicable also to overhead transmission lines, especially where the length is relatively short or where hollow conductors are used.

H. B. DWIGHT (A'11, F'26)

(Professor of electrical machinery, Massachusetts Institute of Technology, Cambridge)

Lighting the New York World's Fair

To the Editor:

I have just gone over the galleys of Mr. R. C. Engelken's article on the lighting of the New York World's Fair shortly to appear in ELECTRICAL ENGINEERING. I want to say that the job could not have been done without the clearheadedness and ingenuity of both Mr. Engelken and Mr. J. S. Hamel. It was a great pleasure to work with them and one of the high spots I shall never forget.

BASSETT JONES

(Consultant to the Board of Design, New York World's Fair 1939)

Computing Light Output

To the Editor:

In illumination problems, it is often necessary to compute the solid angle of a light beam in steradians in order to determine the total flux emitted by the source in lumens. When the plane angle of divergence of the beam is small and, hence, the half angle is small, the use of the common relationship $\omega=2\pi(1-\cos\alpha)$ becomes quite cumbersome. Slide-rule computation of the cosine term is valueless and even the use of four-place trigonometric tables may result in large errors. If, however, the cosine term is expanded in an infinite series, the following result may prove helpful.

$$\omega=2\pi(1-\cos\alpha)$$

$$\cos\alpha=1-\frac{\alpha^2}{2!}+\frac{\alpha^4}{4!}-\frac{\alpha^6}{6!}+\ldots$$

Neglecting the terms to the right of $\frac{\alpha^2}{2!}$:

$$\omega=2\pi\left[1-\left(1-\frac{\alpha^2}{2!}\right)\right]$$

$$\omega=2\pi\times\frac{\alpha^2}{2}$$

$$\omega=\pi\alpha^2$$

ω is the solid angle in steradians subtended by a cone whose plane half angle is α in radians. This relationship is easy to apply and very accurate for total divergence angles up to 20 degrees. Slide-rule calculations are sufficiently accurate.

HERBERT G. BLUMBERG (Enrolled Student)

(University of Michigan, Ann Arbor)

Magnesium-Copper Sulphide Rectifier Battery Charger

To the Editor:

In the December 1939 issue of ELECTRICAL ENGINEERING, I noted some comments by E. A. Hartry on C. A. Kotterman's paper dealing with magnesium-copper sulphide rectifiers for railway battery charging.

To me these comments are neither pertinent to the type of application discussed by Mr. Kotterman, nor correct in their inferences as to the present performance of either magnesium-copper sulphide rectifiers or the plate or sprayed-disc type copper oxide rectifier at high currents.

Outside the laboratory and after aging, the efficiency under service conditions approaches 70 to 75 per cent for copper oxide as against 50 to 55 per cent for magnesium-copper sulphide. However, in the type of work discussed by Mr. Kotterman, as well as in numerous other industrial applications, the limited temperature range and inherent fragility of the copper oxide units more than offsets their moderate advantage in efficiency.

In many industrial applications, the selection of a rectifier is based mainly on consideration of space, weight, cost, temperature limitations, ruggedness, and ability to withstand the abuse inherent in unskilled operation or accommodation of temporary overloads. Whenever any or all of these factors are important, magnesium-copper sulphide rectifiers have very definite advantages to offer.

As to probable life, I should like to point out the fact that the plate or sprayed-disc type copper oxide rectifier and heavy-duty magnesium-copper sulphide rectifier are both relatively new and embrace such radical changes in processing and operation current density as to demand reappraisal of their life expectancy on the basis of their respective field performances. The disappointing and unpredictable performance of early plate type copper oxide rectifiers amply demonstrates the error of basing life expectancy on the performance of the more conservatively engineered low-current copper oxide rectifier. Field tests of the later models of both rectifiers are largely limited to two and one-half years or less, over which period each type has given satisfactory service in those applications to which it has been best suited.

JOSEPH C. RAH (A'22, M'28)

(Consulting engineer, Indianapolis, Ind.)

Time-Saving Method for Calculating Induction-Motor Performance

To the Editor:

For studying the theory and calculating the performance of both single and polyphase induction motors, a great many methods have been proposed. These may be grouped as: (*a*) circle diagram, (*b*) analytical, (*c*) equivalent network, (*d*) auxiliary curves.

Of these (*a*) is used at present mainly for purposes of visualization, while (*b*), (*c*), and (*d*) are used for calculation. Most analytical methods are long[5,6] and require considerable time and labor. The equivalent network scheme, using the circuit of Steinmetz, is in process of adoption by the AIEE. Network methods have been used to some extent. They require a minimum of labor, are accurate, and the physical phenomena may be visualized with greater ease. But many engineers are not familiar with their use. Most textbooks indicate but do not give details of procedure. Auxiliary curves for polyphase motors have been described by W. J. Branson,[4] and for single-phase motors by A. F. Puchstein and T. C. Lloyd.[7] Curves are apt to be bulky and not generally available, though they do save labor. The circle diagram has been superseded in practice mainly because it is less convenient and less accurate than its competitors.

It is the purpose of the present effort to give a method based on the classical equations of coupled circuits and to illustrate the results by numerical examples. Practically all textbooks, particularly those which approach the subject from the standpoint of the transformer, show that a polyphase motor behaves as a transformer whose secondary resistance is equal to r_2/s. By similar reasoning, it follows that the single-phase motor behaves as a transformer with two secondaries, each with one-half the reactance in the polyphase motor and with the resistances $\frac{r_2}{2s}$ and $\frac{r_2}{2(2-s)}$, respectively. This approach requires less labor than most methods and ties together the single-phase and polyphase processes.

Polyphase Motor. The solution in this case has the form:

Primary current,

$$I_1=\frac{Vz_2}{z_1z_2+x_{12}^2} \tag{1}$$

in amperes per phase.

Secondary current,

$$I_2=-\frac{jVx_{12}}{z_1z_2+x_{12}^2} \tag{2}$$

in amperes per phase.

Ratio

$$\frac{I_2}{I_1}=-\frac{jx_{12}}{\frac{r_2}{s}+jx_2} \tag{3}$$

where

r_1 = resistance of primary in ohms per phase

x_1 = total reactance of primary in ohms per phase

$z_1=r_1+jx_1$

r_2 = resistance of secondary reduced to primary in ohms per phase

x_2 = total reactance of secondary reduced to primary in ohms per phase

$z_2=\frac{r_2}{s}+jx_2$

s = slip as a decimal = 0 to 1 in normal operating range

>1 if machine is driven backward against its torque

<0 if machine is driven above synchronism (generator).

x_{12} = mutual reactance between primary and secondary reduced to primary in ohms per phase. It is equal to the magnetizing reactance for the air gap.

[5] For all numbered references, see list at end of letter.

V = primary terminal electromotive force in volts per phase

Special Cases. For certain purposes, for example to draw the circle diagram, it is convenient to have the following points I_1 and I_2 at zero slip, infinite slip, ideal short circuit, etc.

Useful Relations.

$$\text{Torque } T = mI_2^2\frac{r_2}{s} \text{ synchronous watts} \quad (4)$$

$$= \text{secondary input watts.}$$

m = number of primary phases.

Slip at pull-out,[2]

$$s_{po} = \frac{r_2}{x_2}\sqrt{\frac{1+\left(\frac{r_1}{x_1}\right)^2}{\sigma^2+\left(\frac{r_1}{x_1}\right)^2}} \quad (5)$$

where

$$\sigma = 1 - \frac{x_{12}^2}{x_1x_2} = \text{Blondel's leakage factor.} \quad (6)$$

Pull-out torque follows from equations 5, 2, and 4.

Starting torque follows from 2 and 4 with $s = 1$. If desired, convenient curves such as

$$\frac{StT}{POT} = f\left(\frac{r_2}{x_2}\right)$$

may be plotted.

StT = Starting torque
POT = pull-out torque

Reactance for a Given Pull-Out Torque. For any given punchings the ratios $\frac{r_1}{x_1}$, $\frac{r_2}{x_2}$, and $\frac{x_{12}^2}{x_1x_2}$ are nearly constant so long as there is not too much saturation. In any given case, then, these ratios are known or can be found from an exploring calculation. If now the slip at pull-out is found from equation 5, I_2 from 2 substituted in 7, and the result transformed, the following expression for the total reactance and thence the number of turns required to give a prescribed pull-out torque may be obtained:

$$x_1^2 = \frac{mV^2}{T} \cdot \frac{\left(\frac{x_{12}}{x_2}\right)^2 \cdot \frac{r_2}{s_{po}}}{\left(\frac{r_1}{x_1}\cdot\frac{r_2}{x_2s_{po}} + \frac{x_{12}^2}{x_1x_2} - 1\right)^2 + \left(\frac{r_1}{x_1} + \frac{r_2}{x_2s_{po}}\right)^2} \quad (7)$$

Similar expressions have been used in design offices for many years. Their use greatly simplifies and speeds up design procedure, particularly if a list of these ratios has been tabulated. Knowledge of these general facts seems not to have reached design textbooks or electrical-engineering teachers. Similar expressions can be derived also from the equivalent network and in other ways.

If a circle diagram is drawn, I_2 may be measured on the diagram to the same scale as I_1, but the actual value will be (I_2 from circle)$\times\frac{|z_1|}{x_{12}}$. This can be proven by taking the ratio of I_2 from equation 2 to the vector difference between I_1 from equation 1 for slip s and for slip o. This point has puzzled many engineers and few texts explain the reason.

Working Equations and Examples. To illustrate the process, we shall take the main phase of the capacitor motor used by W. J. Morrill[8] and consider it as one phase of a three-phase motor. The constants will be doubled where necessary to give them the values that belong to polyphase operation, thus:

Primary resistance,

$$r_1 = 2.02 = R_{1m}$$

Primary reactance, total,

$$x_1 = 2(33.4+2.79) = 69.59 = 2(X_m + X_{1m})$$

Magnetizing reactance for air gap,

$$x_{12} = 2\times 33.4 = 66.8 = 2X_m$$

Secondary resistance,

$$r_2 = 4.12 = 2R_2$$

Secondary reactance, total,

$$x_2 = 2(33.4+1.06) = 68.92 = 2(X_m + X_2)$$

Iron loss = 24 watts; friction and windage = 13 watts, 60 cycles, 110 volts, 4 poles. Assuming that slip, $s = 0.05$, the work is set up as follows:

$$z_1 = r_1 + jx_1 = 2.02 + j69.59$$

$$\frac{x_{12}^2}{z_2} = \frac{x_{12}^2\left(\frac{r_2}{s} - jx_2\right)}{\left(\frac{r_2}{s}\right)^2 + x_2^2}$$

$$= \frac{66.8\left(\frac{4.12}{0.05} - j68.92\right)}{\left(\frac{4.12}{0.05}\right)^2 + 68.92^2} = 31.88 - j26.66$$

Machine impedance,

$$Z = \text{sum} = 33.90 + j42.93$$
$$= 54.6/\underline{51°40'} \text{ ohms}$$

Primary current in amperes per phase,

$$I_1 = \frac{V}{Z} = \frac{110}{54.6/\underline{51°40'}} = 2.01\sqrt{51°40'}$$
$$= 1.25 - j1.58$$

Adding core loss current,

$$= \frac{Fe}{mV} = \frac{24}{3\times 110} = 0.073$$

Total = $1.323 - j1.58$

Supply current,

$$I = \text{sum} = 1.323 - j1.58 = 2.06\sqrt{50°0'}$$

The core loss can also be included by writing for each, x_1, x_2, and x_{12}, an expression of the form $x(\sin\alpha + j\cos\alpha)$ in equations 1 and 2, etc., where α is the angle of advance due to core loss. Another way is to add the core loss to friction and windage.

Input,

$$P = 3\times 110\times 1.323 = 437 \text{ watts}$$

Secondary current,

$$I_2 = \frac{x_{12}}{|z_2|}I_1 = \frac{66.8\times 2.01}{\sqrt{\left(\frac{4.12}{0.05}\right)^2 + 68.92^2}} = 1.25$$

Torque,

$$T = 3\times 1.25^2\times\frac{4.12}{0.05} = 387 \text{ synchronous watts}$$

$$= \frac{7.04\times 387}{1,800} = 1.51 \text{ pound-feet}$$

Power converted,

$$W_c = (1-s)T = 0.95\times 387 = 368 \text{ watts}$$

Friction and windage loss = 13 watts

Output,

$$W_0 = 355 \text{ watts}$$

Losses,

$$437 - 355 = 82 \text{ watts}$$

Also for check,

Primary copper loss,

$$3I_1^2r_1 = 3\times 2.01^2\times 2.02 = 24.6 \text{ watts}$$

Secondary copper loss,

$$3I_2^2r_2 = 3\times 1.25^2\times 4.12 = 19.4 \text{ watts}$$

Iron loss = 24.0 watts
Friction and windage loss = 13.0 watts
Total loss = 81.0 watts

These results agree closely with those obtained from the equivalent network of Steinmetz. Other networks are suggested in Behrend's "Induction Motor."[9]

Single-Phase Motor. For single-phase operation, as already indicated, the three circuit equations are set up with one-half the values for certain quantities that are used for polyphase motors, thus

$$x_{12}' = \frac{x_{12}}{2},\ r_2' = \frac{r_2}{2},\ x_2' = \frac{x_2}{2}$$

If

f = frequency of supply in cycles per second

I_f = forward rotor current of frequency sf

I_b = backward rotor current of frequency $(2-s)f$

$z_f = \frac{r_2'}{s} + jx_2'$ = rotor impedance to forward current

$z_b = \frac{r_2'}{2-s} + jx_2'$ = rotor impedance to backward current

both reduced to primary in ohms per phase. The solutions are

$$I_1 = \frac{Vz_fz_b}{z_1z_bz_f + x_{12}'^2(z_b+z_f)} \quad (1')$$

$$I_f = \frac{-jVx_{12}'z_b}{z_1z_bz_f + x_{12}'^2(z_b+z_f)} \quad (2')$$

$$I_b = \frac{-jVx_{12}'z_f}{z_1z_bz_f + x_{12}'^2(z_b+z_f)} \quad (3')$$

Special Cases. As before, when it is desirable to have I_1, I_f, and I_b at zero slip, infinite slip, etc., these may be obtained from equations 1′ to 3′.

Working Equations. For this purpose we choose,

$$I_1 = \frac{V}{z_1 + \frac{x_{12}'^2}{z_f} + \frac{x_{12}'^2}{z_b}} \quad (4')$$

$$I_f = \frac{x_{12}'}{|z_f|} I_1 \qquad (5')$$

$$I_b = \frac{x_{12}'}{|z_b|} I_1 \qquad (6')$$

If skin effect is marked as in deep-slot rotors, r_2' and x_2' may be given different values in the forward and backward terms.

Examples and Further Formulas. For this purpose, Morrill's motor with the starting phase open will again be used. The procedure then is at slip

$s = 0.05$:

Primary impedance,

$z_1 = 2.02 + j69.59$

Rotor forward impedance,

$$\frac{x_{12}'^2}{z_f} = \frac{33.4^2\left(\frac{2.06}{0.05} - j34.46\right)}{\left(\frac{2.06}{0.05}\right)^2 + 34.46^2} = 15.91 - j13.31$$

Rotor backward impedance,

$$\frac{x_{12}'^2}{z_b} = \frac{33.4\left(\frac{2.06}{1.95} - j34.46\right)}{\left(\frac{2.06}{1.95}\right)^2 + 34.46^2} = 0.99 - j32.40$$

Machine impedance,

$$\text{sum} = Z = 18.92 + j23.88 = 30.5 \,\underline{/51°40'} \text{ ohms}$$

Primary current,

$$\frac{V}{Z} = \frac{110}{30.5\underline{/51°40'}} = 3.61\sqrt{51°40'} = 2.24 - j2.83$$

Core loss current, primary,

$$\frac{Fe}{2V} = \frac{24}{2 \times 110} = 0.11 + j0$$

Supply current,

$$I = \text{sum} = 2.35 - j2.83 = 3.68\sqrt{50°20'} \text{ amperes}$$

It was assumed that the line supplies one-half the polyphase core loss directly and the rotor the other half$\times(1-s)^2$. If it is assumed that the line supplies all the core loss directly, the results will not differ greatly from those of the equivalent-net-work solution. The method of writing x_1, x_2', and x_{12}' in the form $x(\sin\alpha + j\cos\alpha)$ can also be used.

Secondary forward current,

$$I_f = \frac{33.4 \times 3.61}{\sqrt{\left(\frac{2.06}{0.05}\right)^2 + 34.46^2}} = 2.24 \text{ amperes}$$

Secondary backward current,

$$I_b = \frac{33.4 \times 3.61}{\sqrt{\left(\frac{2.06}{1.95}\right)^2 + 34.46^2}} = 3.49 \text{ amperes}$$

Forward torque,

$$T_f = I_f^2 \cdot \frac{r_2'}{s} = 2.24^2 \times \frac{2.06}{0.05} = 207 \text{ synchronous watts}$$

Backward torque,

$$T_b = I_b \cdot \frac{r_2'}{2-s} = 3.49^2 \times \frac{2.06}{1.95} = 13 \text{ synchronous watts}$$

Resultant torque,

$$T = T_f - T_b = 207 - 13 = 194 \text{ synchronous watts}$$

Power converted,

$W_c' = (1-s)T = 0.95 \times 194 = 184$ watts

Iron loss carried by rotor,

$$(1-s)^2\frac{Fe}{2} = 0.95^2 \times 12 = 11 \text{ watts}$$

Power converted,

$W_c = 184 - 11 = 173$ watts

Friction and windage $= 13$ watts
Output $= 160$ watts

Shaft torque,

$$\frac{160}{1-.05} = 168 \text{ synchronous watts, or}$$

$$\frac{112.5 \times \text{synchronous watts}}{\text{syn.}} = 10.5 \text{ ounce-feet,}$$

where "syn" is the synchronous speed in revolutions per minute.

Input,

$W_i = 110 \times 2.35 = 258$ watts

Losses,

$258 - 160 = 98$ watts

Also for check,
Iron loss,

$12 + 11 = 23$ watts
Friction and windage $= 13$ watts

Primary copper loss,

$I_1^2 r_1 = 2.61^2 \times 2.02 = 26.4$ watts

Secondary copper loss, forward,

$I_f^2 r_2' = 2.24^2 \times 2.06 = 10.7$ watts

Secondary copper loss, backward,

$I_b^2 r_2' = 3.69^2 \times 2.06 = 25.1$ watts
Total loss $= 98.2$ watts

Slip at Pull-Out. An expression for this can be derived in a manner similar to that outlined for the polyphase motor. This leads to a sixth degree equation which is not suitable for practice. In its stead, a process outlined by C. G. Veinott[1,6] may be used. Let

$$\alpha = \frac{1}{2}\,\text{ctn}^{-1}\frac{r_2}{X} \cong \frac{1}{2}\,\text{ctn}^{-1}\frac{4.12}{4.91} = 25°0'$$

$X \cong x_1 + x_2 = 2.79 + 2.12 = 4.91$

$\tan\alpha = 0.466$,

then speed at pull-out,

$$S_{po} \cong \sqrt{1 - 1.05\tan\alpha \cdot \frac{r_2}{X}} = \sqrt{1 - 1.05 \times 0.466 \times \frac{4.12}{4.91}} = 0.768 \qquad (7')$$

and slip at pull out $= s_{po} \cong 1 - 0.768 = 0.232$.

Reactance to Give a Prescribed Pull-Out Torque. When the ratios $\frac{r_1}{x_1}$, $\frac{r_2'}{x_2'}$ and $\frac{x_{12}'^2}{x_1 x^2{}'}$ for a set of punchings to be used are known, let

$$r_f = \frac{r_2'}{s}, \quad r_b = \frac{r_2'}{2-s}$$

$$a = r_f\left[1 + \left(\frac{r_f}{x_2'}\right)^2\right]$$

$$b = r_b\left[1 + \left(\frac{r_b}{x_2'}\right)^2\right]$$

$$A = \frac{r_1}{x_1} \cdot \frac{r_b}{x_2'} \cdot \frac{r_f}{x_2'} + \frac{x_{12}'^2}{x_1 x_2} \cdot \left(\frac{r_b}{x_2'} + \frac{r_f}{x_2'}\right) - \left(\frac{r_1}{x_1} + \frac{r_b}{x_2'} + \frac{r_f}{x_2'}\right)^2$$

$$B = \left[\frac{r_1}{x_1} \cdot \frac{r_b}{x_2'} + \frac{r_b}{x_2'} \cdot \frac{r_f}{x_2'} + \frac{r_1}{x_1} \cdot \frac{r_f}{x_2'} + \frac{2x_{12}'^2}{x_1 x_2'} - 1\right]^2$$

then

$$x_1^2 = \frac{V^2}{T} \cdot \left(\frac{x_{12}'}{x_2'}\right)^2 \cdot \frac{a-b}{A+B} \text{ ohms}^2 \qquad (8')$$

These relations can be further simplified for practice and have been so used for many years. When x_1 is known, the number of stator turns required to give a specified pull-out torque follow at once.

Ideal No-Load Speed. When there is no iron loss and no friction, the torque is zero when

$T_f = T_b$

Making the appropriate substitutions,[3] this gives for the corresponding slip

$$s_0 = \sqrt{1 - \left(\frac{r_2'}{x_2'}\right)^2} \qquad (9')$$

REFERENCES

1. Single-Phase Induction Motor, **W. J. Branson.** AIEE Transactions, volume 31, part 2, 1912, pages 1749–87.

2. The Pull-Out Torque of the Polyphase Induction Motor (in German), **L. Dreyfus.** Vesterås, Sweden. *Archiv. für Elektrotechnik,* volume 15, 1925.

3. The Cross-Field Theory of A-C Machines, **H. R. West.** AIEE Transactions, volume 45, 1926, pages 466–72.

4. Polyphase Induction Motors, **W. J. Branson.** AIEE Transactions, volume 49, 1930, pages 319–28.

5. Induction Motor Performance Calculations, **P. L. Alger.** AIEE Transactions, volume 49, 1930, pages 1055–66.

6. Performance Calculations on Induction Motors, **C. G. Veinott.** AIEE Transactions, volume 51, 1932, pages 743–54.

7. Single-Phase Induction Motor Performance, **A. F. Puchstein** and **T. C. Lloyd.** Electrical Engineering, October 1937, pages 1277–84.

8. Revolving Field Theory of the Capacitor Motor, **W. J. Morrill.** AIEE Transactions, volume 48, 1929, pages 614–29.

9. The Induction Motor (a book), **B. A. Behrend.** McGraw-Hill Book Company, New York, 1921, pages 44, 208–09, 228.

A. F. Puchstein (A'20, M'27)

(Consulting engineer, Robbins and Myers, Inc., Springfield, Ohio)

Books Received

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

THE THEORY AND USE OF THE COMPLEX VARIABLE. By S. L. Green. New York and Chicago, Pitman Publishing Corporation, 1939. 136 pages, diagrams, 9 by 6 inches, cloth, $3.00. An introductory account of the subject of the complex variable and conformal transformation, with some indication of applications to problems of mathematical physics, aeronautics, and electrical engineering. The mathematical requirements comprise some knowledge of calculus and analytical plane geometry. Exercises are included.

LUBRICANTS AND LUBRICATION. By J. I. Clower. New York and London, McGraw-Hill Book Company, 1939. 464 pages, illustrated, 9 by 6 inches, cloth, $5.00. The first ten chapters present the fundamentals of lubricants and lubrication in such a way as to enable the student to analyze the requirements of most equipment. The following six chapters apply the basic principles to various machines and make specific recommendations for the analysis of equipment.

SCIENCE TODAY AND TOMORROW. By W. Kaempffert. New York, The Viking Press, 1939. 275 pages, tables, 8½ by 5 inches, cloth, $2.50. The great events on the horizon in astronomy, physics, chemistry, biology, electricity, and other sciences are presented in non-technical language. The author also predicts some probable or possible future extensions and their influence on the social organization.

SPARKS, LIGHTNING, COSMIC RAYS. An Anecdotal History of Electricity. By D. C. Miller. New York, Macmillan Company, 1939. 192 pages, illustrated, 9 by 6 inches, cloth, $2.50. Embodies the Christmas lectures for young people at the Franklin Institute, 1937. The nature of electricity, from the experiments with amber by the Greek philosophers to the latest phenomena of cosmic rays, is presented by anecdotal reference to the many significant experiments and discoveries made by the important workers in that field. The second section of the three comprising the book is devoted to Benjamin Franklin.

SUPERCONDUCTIVITY. By D. Shoenberg. Cambridge, England, University Press; New York, Macmillan Company, 1938. 111 pages, diagrams, charts, 8½ by 5½ inches, paper, $1.75. The phenomenon of superconductivity as exhibited by certain metals, metallic compounds, and alloys is discussed, mainly from the point of view of recent developments. The experimental results cited are for the purpose of making clear the essential principles involved. References with each chapter and with the appendix of numerical data.

STRATEGIC MINERAL SUPPLIES. By G. A. Roush. New York and London, McGraw-Hill Book Company, 1939, 485 pages, diagrams, etc., 9½ by 6 inches, cloth, $5.00. Presents a concise picture, from both a military and general industrial viewpoint, of the status of the United States with respect to supplies of those materials of mineral origin of which the domestic supply is inadequate. Twelve minerals, mostly metals, are discussed in detail as to uses, substitutes, ore reserves, sources of supply, imports, exports, stocks, tariff, and political and commercial control, as they affect the domestic situation.

AMERICAN DIESEL ENGINES. By L. H. Morrison. Second Edition. New York and London, McGraw-Hill Book Company, 1939. 489 pages, illustrated, 9½ by 6 inches, cloth, $5.00. Planned to give factory executives and operating engineers information that will enable them to select the best engine for their purposes, and operate and maintain it efficiently. It includes detailed descriptions of all American-made engines. The new edition has been revised extensively.

INTERNAL COMBUSTION ENGINES. By L. C. Lichty. Fifth edition. New York and London, McGraw-Hill Book Company, 1939, 603 pages, illustrated, 9 by 6 inches, cloth, $4.50. This textbook first develops the theoretical principles and then illustrates their application to the analysis, design, and operation of the internal-combustion engine and its parts. Changes include a simplification of the method of analyzing thermodynamic processes, a chapter on air-standard cycle analysis, revision of the chapters on fuels, detonation and fuel injection, more material on combustion-chamber design and air cooling, and thorough revision throughout. Previous editions were under joint authorship of Robert L. Streeter.

THE RECTIFICATION OF ALTERNATING CURRENT. By H. Rissik. London, English Universities Press; Hodder and Stoughton, 1938. 219 pages, illustrated, 9 by 6 inches, cloth, 21s. Fundamental circuit relations and the general characteristics of rectifier circuits are discussed in Part I. Part II covers the physical principles underlying rectification phenomena, electric discharges, boundary layers, etc. In Part III four methods of a-c rectification are described: mechanical, electron discharge, arc discharge, and by unipolarity of boundary layers. The book is intended for both students and practicing engineers and has a large bibliography.

ABSORPTION SPECTROPHOTOMETRY AND ITS APPLICATIONS; Bibliography and Abstracts 1932 to 1938. By O. J. Walker. London, England, Adam Hilger, Ltd., 1939. 68 pages, 10 by 6 inches, linen, apply. A comprehensive list of references covering the developments and applications of absorption spectrophotometry for the period 1932 to 1938. In order to facilitate the task of obtaining quantitative absorption data concerning any particular problem, the references have been classified under various general headings and are numbered serially. There is an author index.

ATM (Archiv für technisches Messen) Lfg. 97 and 98, July and August, 1939. Munich and Berlin, R. Oldenbourg. Pages T85–112, illustrated, 12 by 8 inches, paper, 1.50 rm. each. Two numbers of a monthly publication containing classified articles upon various types of apparatus and methods for technical measurements. Certain numbers also contain descriptions of specific instruments manufactured by German companies.

AUDEL'S NEW RADIOMAN'S GUIDE. By E. P. Anderson. New York, Theo. Audel and Company, 1939, 756 pages, illustrated, 7 by 5 inches, cloth, $4.00. Covers the fundamentals of sound, electricity, and radio principles; describes broadcasting and receiving equipment, including design, operation, and maintenance details; and discusses allied apparatus, such as marine and aircraft communication, public address systems, the radio compass and beacons, automatic alarms, and electronic television. Underwriters' standards, symbols, abbreviations, and units are given, and questions or problems with answers are included in various chapters.

Deutsches Museum, Abhandlungen und Berichte, Jg. 11, Heft 2. GEORG SIMON OHM, by J. Zenneck. Berlin, VDI-Verlag, 1939, 57 pages, illustrated, 8 by 6 inches, paper, 0.90 rm. The life and work of Ohm are briefly related, with a further section discussing Ohm as a teacher, the recognition he received, and his personal appearance. Short bibliography.

DIESEL ENGINEERING HANDBOOK 1939–1940. De luxe edition. Edited by L. H. Morrison. New York, Diesel Publications, 1939, 940 pages, illustrated, 9 by 6 inches, cloth, $6.00. This handbook, revised and enlarged, provides practical up-to-date information upon the operation and maintenance of Diesel engines, valuable both to the owner and operator. The treatment is exhaustive and profusely illustrated from actual practice. Two chapters of engineering fundamentals are devoted to brief description of useful general engineering terms and equipment.

FAULTS AND FAILURES IN ELECTRICAL PLANT. By R. Spieser and others; translated by E. Hunking. London, Sir Isaac Pitman and Sons; New York, Pitman Publishing Corporation, 1939, 408 pages, illustrated, 8 by 6 inches, cloth, $10.00. The paucity of collected information on electrical plant troubles has inspired the translation from the German of this book on the causes, results, cure, and prevention of faults and failures in heavy current machines, apparatus, and plant. The first three parts cover installation and operational faults of electrical machines, transformers, and auxiliary apparatus. Part IV considers the materials employed and the troubles directly resulting from them.

HUMAN-RELATIONS MANUAL FOR EXECUTIVES. By C. Heyel. New York and London, McGraw-Hill Book Company, 1939, 253 pages, diagrams, etc., 8 by 5 inches, cloth, $2.00. Ideas for selecting, developing, stimulating, safeguarding, and guiding the working force are presented in the form of case examples of what actual companies are doing successfully to solve their personnel problems. Application check points, consisting of pertinent questions on the preceding material, accompany each chapter.

INTRODUCTION TO CHEMICAL PHYSICS. By J. C. Slater. New York and London, McGraw-Hill Book Company, 1939. 521 pages, diagrams, etc., 9 by 6 inches, cloth, $5.00. The purpose of this book is to provide a unified presentation of the subjects common to both physics and chemistry, especially for those who wish to obtain the maximum knowledge of chemical physics with the minimum of theory.

MARINE DIESEL MANUAL. Edited by L. R. Ford. Diesel Publications, New York, 1939, 207 pages, illustrated, 6 by 5 inches, paper, $0.50. Covers the principles, types, and details of marine Diesel engines, including fuel systems, lubrication, operation and maintenance instructions, auxiliary equipment, and electric and gear drives.

MATTER AND LIGHT, THE NEW PHYSICS. By L. de Broglie; translated by W. H. Johnston. New York, W. W. Norton and Company, 1939, 300 pages, diagrams, etc., 9 by 5 inches, cloth, $3.50. A collection of studies on contemporary physics, some written from the general and others from a more metaphysical point of view. The subjects include a general survey of contemporary physics, matter and electricity, light and radiation, wave mechanics, philosophical studies on quantum physics, and other philosophical studies.

ASTM STANDARDS ON ELECTRICAL INSULATING MATERIALS. Specifications, Methods of Testing. Prepared by Committee D-9. October 1939. Philadelphia, American Society for Testing Materials. 309 pages, illustrated, 9 by 6 inches, paper, $2.00 (ASTM members, $1.50). In addition to the current report of the responsible committee, this pamphlet contains 11 standard and 18 tentative methods of testing for electrical insulating materials, and also 3 specifications. In addition, there are 10 specifications covering certain rubber and textile products and methods of testing shellac.

ELECTRICAL COMMUNICATION. By A. L. Albert. Second edition. John Wiley and Sons, New York, 1940. 534 pages, illustrated, 9½ by 6 inches, cloth, $5.00. This textbook covers the whole field of electrical communication by wire and wireless transmission of code and speech. Telegraphy, telephony, and radio are treated not as isolated subjects, but to show their interrelations in providing an adequate, economical communication service. This edition has been revised and enlarged, and bibliographies brought up to date.

ELECTRICAL TIMEKEEPING. By F. Hope-Jones, with a foreword by H. S. Jones. N.A.G. Press, Ltd., London, 1940. 275 pages, illustrated, 9 by 5½ inches, cloth, 10s. An horologist gives an account of the efforts, extending over 100 years, to obtain accurate timekeeping by the application of electricity. Includes a digest of the historical chapter of "Electric Clocks", by the same author. It also sets forth the principles essential to accurate timekeeping, describes the theory of the free pendulum and its application, and considers synchronous-motor clock, telescope drives, and other horological matters.

ENGINEERING DRAWING, PRACTICE AND THEORY. By I. N. Carter. Scranton, Pa., International Textbook Company, 1939. 264 pages, illustrated, 11½ by 8½ inches, cloth, $2.50. Combines descriptive geometry and engineering drawing in a single course of study covering both theory and practice. Considerable saving of time by elimination of duplication of classroom work is claimed. The book covers the fundamental principles of machine, structural, and topographic drafting, according to accepted drafting-room methods.

FUNDAMENTAL PROCESSES OF ELECTRICAL DISCHARGE IN GASES. By L. B. Loeb. New York, John Wiley and Sons, 1939. 717 pages, illustrated, 9 by 6 inches, cloth, $7.00. The topics discussed comprise ionic mobilities, ionic and electronic recombination processes, diffusion of ions and electrons, electron mobilities, energy distribution functions of electrons in gases, electron-attachment and negative-ion formation, conduction currents, and the Townsend coefficients. Each is introduced from the classical point of view and carried through the subsequent experimentation and theory to the present-day interpretation. The final chapters present the application to the problems of spark discharge, the glow, and the arc. References.

Great Britain, Mines Department. REPORT OF H.M. ELECTRICAL INSPECTOR OF MINES FOR THE YEAR 1938. London, His Majesty's Stationery Office, 1939. 45 pages, tables, 10 by 6 inches, paper, 9d. (Obtainable from British Library of Information, 50 Rockefeller Plaza, New York, 25c.) In addition to statistics on the electrical equipment used in the mines, the report contains statistics and analyses of accidents attributed to the use of electricity.

HANDBOOK OF PHOTOGRAPHY. Edited by K. Henney and B. Dudley. McGraw-Hill Book Company, Whittlesey House, New York, 1939. 871 pages, illustrated, 9 by 6 inches, leather, $7.50. A one-volume encyclopedia of photography, the work of 23 specialists, presents the technique of the photographic process and the scientific basis underlying photography and its applications. Photomicrography, motion pictures, color, speed, and infrared photography, and other specialized adaptations are covered. Bibliographies and reference tables.

PRINCIPLES OF TELEVISION ENGINEERING. By D. G. Fink. McGraw-Hill Book Company, New York and London, 1940. 541 pages, illustrated, 9½ by 6 inches, cloth, $5.00. Gives information on the fundamental processes of television reception and transmission, and also on design and modern equipment. The presentation is arranged in the logical sequence of events in television transmission, beginning with the camera, through the subsidiary amplifying and transmitting equipment, radiation through space, reception and amplification, detection and image reproduction. Standards, recommended practices, definitions, and names of controls are appended.

Institute Activities

Preliminary Program Arranged for 1940 Summer Convention at Swampscott

The 1940 AIEE summer convention, which will be held in Swampscott, Mass., June 24–28, will provide a business and technical program of broad interest, with opportunity for sports, trips, and social recreation. Swampscott, on Boston's north shore, affords unlimited opportunity for healthful outdoor enjoyment, and the committee expects to make this convention a gathering place for many family groups. The technical program has been so arranged that the sessions on communication and electronics, as well as the frequency-modulation demonstration, occur during the early part of the convention to permit members interested in these subjects to attend the 15th annual convention of the Institute of Radio Engineers, at Hotel Statler, Boston, Mass., June 27–29. Members also are reminded that as the semiannual meeting of The American Society of Mechanical Engineers is being held in Milwaukee, Wis., June 17–20, those traveling from the west may conveniently attend both meetings.

FREQUENCY-MODULATION DEMONSTRATION

Wednesday evening, June 26, a talk on frequency modulation, with demonstrations, will be given by W. L. Everitt, Ohio State University. The talk will cover the history of frequency modulation, its fundamental principles of operation, what it aims to accomplish, and a comparison of its results with those which can be obtained by amplitude modulation at both broadcast and ultrahigh frequencies.

One of the most dramatic effects of frequency modulation will be shown, that is, that when two stations are operating on the same frequency, if one signal exceeds the other by a ratio of two to one or more, only the louder signal is heard. To demonstrate this two small frequency-modulated transmitters which operate on the same frequency and whose output can be controlled by Variacs in the plate supply of the final amplifiers are used. By controlling the output of either or both of these transmitters one or the other signal can be made to dominate. The transmitters will be amplitude-modulated as well, to show the difference between the two types of modulation. Speech is used to modulate one transmitter and music on the other.

Arrangements have been made through the Yankee Network to make a special broadcast from Paxton to show the high quality that can be obtained from a station some 50 miles away.

TECHNICAL CONFERENCES

Seven technical conferences have been tentatively scheduled on the following subjects: communication networks, standards, load swings, test codes, nonlinear analysis, introducing modern statistical technique to electrical engineers, and dielectric measurements in the field. The scope and objectives in so far as known are given. Although some of the material in the conferences is the basis of committee work the general membership is invited to attend and participate freely in the general discussion.

Standards (Tuesday, June 25, 2:00 p.m.). Subjects to be discussed are: first, the work for the proposed co-ordinating committee 7 on conduction; second, the scope of co-ordinating committee 5 on basic theories and units; and, third, a discussion of short-time ratings of apparatus continuing the work of co-ordinating committee 4, which has been revising Standard No. 1.

As work for the proposed co-ordinating committee 7 on conduction, the co-ordination of ratings of wire and conductors with

Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held at the New Ocean House, Swampscott, Mass., at 10 a.m. on Monday, June 24, 1940. This will constitute one session of the summer convention.

At this meeting, the annual report of the board of directors and the report of the committee of tellers on the ballots cast for the election of officers will be presented.

Such other business, if any, as properly may come before the annual meeting may be considered.

(*Signed*) H. H. Henline
National Secretary

Tentative Schedule of Events

All Sessions and Conferences Will Be Held at the New Ocean House

Monday, June 24

Morning	Registration
10:00 a.m.	Annual Meeting Reports, presentation of prizes for papers, presentation of Lamme Medal, and president's address
2:00 p.m.	Conference of officers, delegates, and members
4:00 p.m.	Women's tea and musicale
Evening	Dance and reception

Tuesday, June 25

Morning	Opening of women's golf tournament
9:00 a.m.	Electronics
9:00 a.m.	Power transmission
9:00 a.m.	Standards
9:00 a.m.	Automatic stations and basic sciences
Noon	Luncheon for women golfers at Tedesco Country Club
Afternoon	Putting contest with prizes for women not in tournament
2:00 p.m.	Conference of Student Branch counselors
2:00 p.m.	Conference on communication networks
2:00 p.m.	Conference on standards
2:00 p.m.	Conference on load swings
Afternoon	Deep-water cruise on fishing schooner "Gertrude L. Thebaud"—tickets $2.50
Evening	Searchlight drill by naval vessels off Swampscott shore Special motion pictures in ballroom

Wednesday, June 26

9:00 a.m.	Communication
9:00 a.m.	Transportation
9:00 a.m.	Testing of insulation
2:00 p.m.	Conference of officers, delegates, and members, continued
Afternoon	Bridge party for women
Evening	Shore dinner on the rocks and beach adjoining New Ocean House Frequency-modulation demonstration Dancing

Thursday, June 27

10:00 a.m.	Joint general session with the American Engineering Council
Noon	Board of directors luncheon meeting
2:00 p.m.	Conference on test codes
2:00 p.m.	Conference on nonlinear analysis
2:00 p.m.	Conference on introducing modern statistical technique to electrical engineers
2:00 p.m.	Conference on dielectric measurements in the field
Evening	Formal banquet and dance—special decorations, award of women's sport prizes, and orchestral music

Friday, June 28

9:00 a.m.	Protective devices
9:00 a.m.	Instruments and measurements
9:00 a.m.	Electrical machinery

ratings of the apparatus they serve, has been suggested. This would probably involve such questions as the rating of fuses, circuit breakers, starting currents, short and overtime ratings, flicker, etc.

As scope for the work of co-ordinating committee 5 discussion will evolve about the use of the rationalized system for deriving the basic units.

Load Swings (Tuesday, June 25, 2:00 p.m.). This conference sponsored by the committee on power generation will be devoted to the subject of load swings as related to turbine-generator governing and stability. A subcommittee is preparing a program which it is hoped will be augmented by voluntary contributions from those in attendance. From the discussion evolved specific topics will be selected and authors invited to prepare formal papers for the winter convention.

Introducing Modern Statistical Technique to Electrical Engineers (Thursday, June 27, 2:00 p.m.). This conference is intended to show to those unacquainted with statistical methods what information and economy may be secured by this technique and how statistics will add to the effectiveness of engineering effort. Informal talks will be given on statistical control in manufacturing, statistics applied to research, the building up of engineering tolerances, and statistical quality control. Following these talks a general discussion will be lead by Doctor W. S. Shewhart, Bell Telephone Laboratories, Inc.; Doctor R. Rudenberg, Harvard University; and A. J. Lacock, General Electric Company. In this conference attempts will be made to discuss the use of the statistical method by means of concrete cases rather than theory, but for those interested in the subject a book by Doctor Shewhart entitled "Statistical Method From the Viewpoint of Quality Control," is recommended to render the discussion more interesting.

INSPECTION TRIPS

On Tuesday, June 25 and Wednesday, June 26, trips are being arranged to interesting industrial plants, such as Champion Lamp Works, Christian Science Publishing Society, General Electric Company, Hygrade-Sylvania Corporation, Lynn Gas and Electric Company, North Eastern Telephone and Telegraph Company—Lynn Exchange, Naumkeag Steam Cotton Company, and United Shoe Machinery Company. On Wednesday, plans have been made for an industrial trip to L Street Station, Boston Edison Company, Boston Fish Pier, and Sumner Tunnel, and a scenic and historical trip to Lexington, Concord, and Bunker Hill, and on Thursday, for visits to Harvard University and Massachusetts Institute of Technology (atom-smashing, wind-tunnel, etc.), and for a trip around historic Boston, including the glass flowers at Harvard.

SPORTS

Throughout the convention facilities will be available for golf, tennis, sailing, soft ball, horse shoes, fish, and chips. As usual, there will be the annual tournaments for the Mershon golf and tennis trophies and the medal play for the Lee trophy.

National • • • •

First Fortescue Fellowship Awarded

Norman Z. Alcock, Kingston, Ontario, Canada, has been chosen to receive the Charles LeGeyt Fortescue Fellowship for 1940–41, the first to be awarded. Terms and provisions of the fellowship, which is administered by a special committee of the AIEE, were described in the January 1940 issue, page 42. Mr. Alcock, who graduates this year from Queens University, Kingston, will use the award for graduate study in electrical engineering at California Institute of Technology, specializing in

Tentative Technical Program (in Part)

Tuesday, June 25

9:00 a.m. Standards

40-92. REFERENCE VALUES FOR TEMPERATURE, PRESSURE, AND HUMIDITY. **P. L. Bellaschi** and **P. H. McAuley,** Westinghouse Electric and Manufacturing Company

40-93. RATIONALIZATION OF SHORT-TIME AND INTERMITTENT RATINGS OF ELECTRICAL APPARATUS AND WIRING. **R. E. Hellmund** and **P. H. McAuley,** Westinghouse Electric and Manufacturing Company

40-94. RATING OF POTENTIAL DEVICES. **P. O. Langguth,** Westinghouse Electric and Manufacturing Company, and **J. E. Clem,** General Electric Company

40-95. STANDARDIZATION PROBLEMS ON FRACTIONAL-HORSEPOWER MOTORS. **C. G. Veinott,** Westinghouse Electric and Manufacturing Company

40-96. EFFECT OF LOAD FACTOR ON OPERATION OF POWER TRANSFORMERS BY TEMPERATURE. **V. M. Montsinger,** General Electric Company

Wednesday, June 26

9:00 a.m. Testing of Insulation

40-81. LOW-VOLTAGE D-C MEASUREMENTS ON ELECTRICAL INSULATING OILS. **J. L. Onclay** and **W. C. Hollibaugh,** Massachusetts Institute of Technology

40-82. RAPID RECORDING ALTERNATING-CURRENT BRIDGE. **W. Mikelson** and **H. W. Bousman,** General Electric Company

40-84. A METHOD FOR DETECTING THE IONIZATION POINT OF ELECTRICAL APPARATUS. **G. E. Quinn,** Consolidated Edison Company of New York, Inc.

Photo-offset copies of authors' manuscripts, except addresses, may be obtained in advance of the convention by writing to the AIEE Order Department, 33 West 39th Street, New York, N. Y. Only numbered papers will be available in advance-copy form. If ordered by mail, price 10 cents per copy; if purchased at Institute headquarters or at the convention, 5 cents per copy. Mail orders (particularly from out-of-town members) are advisable, inasmuch as an adequate supply of each paper at the meeting cannot be assured. Coupon books in $1.00 and $5.00 denominations are available for those who wish to avoid remittance by check or otherwise. Most of the papers ultimately will be published in ELECTRICAL ENGINEERING or the TRANSACTIONS.

Friday, June 28

9:00 a.m. Protective Devices

40-85. A HIGH POWER OIL-LESS CIRCUIT INTERRUPTER USING WATER. **W. M. Leeds,** Westinghouse Electric and Manufacturing Company

40-103. A HIGH-SPEED DIFFERENTIAL RELAY FOR GENERATOR PROTECTION. **W. K. Sonneman,** Westinghouse Electric and Manufacturing Comany.

9:00 a.m. Instruments and Measurements

40-88. AN IMPROVED TYPE OF DIRECT-CURRENT WATTMETER OF THE SHUNTED TYPE. **Paul MacGahan,** Westinghouse Electric and Manufacturing Company

40-89. COMPUTATION OF ACCURACY OF CURRENT TRANSFORMERS. **A. T. Sinks,** General Electric Company

40-90. NEW INSTRUMENTS FOR RECORDING LIGHTNING CURRENTS. **C. F. Wagner** and **G. D. McCann,** Westinghouse Electric and Manufacturing Company

40-91. THE OUTPUT AND OPTIMUM DESIGN OF PERMANENT MAGNETS SUBJECTED TO DEMAGNETIZING FORCES. **A. J. Hornfeck,** Bailey Meter Company, and **R. F. Edgar,** General Electric Company

40-97. A NEW HIGH-SPEED THERMAL WATTMETER. **John H. Miller,** Weston Electrical Instrument Corporation

9:00 a.m. Electrical Machinery

40-98. AN EXTENSION OF THE METHOD OF SYMMETRICAL COMPONENTS USING LADDER NETWORKS. **Waldo V. Lyon,** Massachusetts Institute of Technology

40-99. EFFECTIVE RESISTANCE TO ALTERNATING CURRENTS OF MULTI-LAYERED WINDINGS. **Edward Bennett,** University of Wisconsin, and **Sidney C. Larson,** General Electric X-Ray Corporation

40-100. TRANSIENT STARTING TORQUES IN INDUCTION MOTORS. **A. M. Wahl** and **L. A. Kilgore,** Westinghouse Electric and Manufacturing Company

40-101. DEAD POINTS IN SQUIRREL-CAGE MOTORS. **Quentin Graham,** Westinghouse Electric and Manufacturing Company

40-102. PERFORMANCE OF TRAVELING WAVES IN COILS AND WINDINGS. **R. Rudenberg,** Harvard University

NOTE Papers tentatively scheduled for the technical sessions in so far as known at the time of going to press are announced. Papers to be scheduled in the remaining sessions will be announced in the June issue of ELECTRICAL ENGINEERING.

Future AIEE Meetings

Summer Convention
Swampscott, Mass., June 24–28, 1940

Pacific Coast Convention
Los Angeles, Calif., August 26–30, 1940

Middle Eastern District Meeting
Cincinnati, Ohio, October 9–11, 1940

Winter Convention
Philadelphia, Pa., January 27–31, 1941

communications under Professor R. W. Sorensen. He has won six scholarships and prizes during his course at Queens, which he entered on the Sir Sandford Fleming matriculation scholarship in 1936.

1940 Year Book Available

The 1940 edition of the AIEE Year Book has been issued, in accordance with 1939–40 budget provisions. Addresses are corrected as of February 29, 1940. Copies already have been distributed to all national, District, and Section officers, Student Branch counselors, and all members of national committees. Other members desiring copies may secure them by writing to the AIEE order department, 33 West 39th Street, New York, N. Y. The Year Book is not available to nonmembers of the Institute, nor its use permitted for commercial, promotional, or other circularization purposes.

Section

Programs Contribute to Community Life

In Pittsfield, Mass., the AIEE Section has fostered a program of activities from which the citizens of the town benefit greatly. For a small charge, they may attend educational lectures on astronomy, exploration, zoology, aviation, photography, medicine, and similar subjects.

The Section's activities consist of a series of popular lectures, a series of technical lectures, not necessarily concerned with members' own work, and a series of colloquia, highly technical discussions of specific interest to the members and their jobs.

To attend the five popular lectures each year nonmembers of the Institute must become local members of the Section, at a charge of $1.50, with no guest privilege. To attend the technical-lecture series local members must buy another ticket for $1.00.

Formerly, the Section sold for $2.00 tickets which entitled the holder and a woman guest to attend all popular and technical lectures. The price was increased partly to maintain a high standard and partly because speakers were costing more, but mainly because the number of people who wanted tickets became overwhelming. Even with the higher charge the Section had to limit the number of tickets sold.

For several years, the local membership has averaged between 1,100 and 1,400. About 400 tickets are given to Institute members and their wives. The maximum capacity of the auditorium is 1,500.

Formerly the popular lecture tickets were sold to students for $1.00. Because of the auditorium's limited capacity, however, the Section now arranges to have all suitable lectures repeated at the high school. The Section negotiates with the speakers to present the talks at a low price, and the high-school authorities pay the speakers and collect a small fee from the students.

Competitions Encourage Technical and Popular Papers

Two local conventions are held each year by the Lynn Section, one for a technical paper competition and the other for presentation of papers on popular subjects.

Intended for young men who have not previously delivered papers before a national or District meeting, the technical paper competition is open to any national or local member under 35 years of age who has not previously won a first prize. Papers may be on any technical subject. Written papers are first graded by three judges and the eight best ones are selected, for presentation in 15-minute speeches at the first of the local conventions. Awards are made on the basis of 40 per cent for the written paper itself, 40 per cent for the oral presentation, and 20 per cent for the popular vote. Prizes for the winning papers are $15, $10, and $5.

The popular papers, presented at the second local convention, usually have to do with personal hobbies. The six best-written papers are selected for oral presentation and three prizes awarded. Last year an exhibit of color photography, a speech on a historical collection of stockings, and a ventriloquist act won the prizes.

About 100 people attended the technical paper contest and 500 the popular paper convention in 1938–39.

Movies Start Section Meetings. The plan of showing a short motion picture at the beginning of Section meetings has been adopted by the Philadelphia Section to increase interest and solve the problem of late-comers. Habitually tardy members only miss a part of the film and do not disturb the rest of the audience, whereas starting the meetings late to avoid having talks interrupted by late-comers seemed to annoy the more punctual. Films lasting about 15 or 20 minutes have been found most satisfactory. Usually technical or descriptive, the films are most often those distributed free by industrial companies, although some cartoons have been shown. In order to test the members' reaction to the use of movies, which is believed generally favorable, the program committee recently decided to omit films for a few meetings.

Students Entertained. Each month four members of the Los Angeles Section entertain four students, two from the University of Southern California and two from the California Institute of Technology. A list of prospective hosts has always been available since the practice began. Each student is asked to prepare a five-minute talk on any subject he chooses.

Branch

Branch Convention Held at Pratt Institute

The 14th annual convention of AIEE Student Branches in the New York City District (3) was held April 25, 1940, at Pratt Institute School of Science and Technology, Brooklyn, N. Y. In addition to seven local inspection trips and inspection of the Pratt Institute shops and laboratories, the convention program included a technical session at which the following student papers were scheduled:

An Electronic D-C Transformer, **C. Conrad Dalman**, College of the City of New York

A High-Quality Broadcast Radio Receiver, **William R. Hutchins**, Columbia University

Mapping of an Electrostatic Field, **Laurence Bershad**, Polytechnic Institute of Brooklyn

Constant Potential D-C Power Supply, **Harold F. Brown**, Pratt Institute

The Method of Selective Remote Control by Audio Signal, **Stanton Shackell**, Rutgers University

Automatic Slide-Back Vacuum Voltmeter, **Philip Volz**, Newark College of Engineering

Awards for papers were made to: William R. Hutchins, first prize; Philip Volz, second prize; Stanton Shackell, honorable mention. The prizes were presented at a banquet at which featured speakers were Doctor C. F. Scott, professor emeritus, Yale University, and founder of AIEE Student Branches, and E. A. Baldwin, manager of Paris office and vice-president, International General Electric Company. Guests of honor included President F. Malcolm Farmer and National Secretary Henline of the AIEE. George A. Doxey, chairman of the Pratt Institute Branch, was chairman of the convention. Besides those represented on the technical program, the following Student Branches are included in District 3: Cooper Union Institute of Technology, New York, N. Y., Stevens Institute of Technology, Hoboken, N. J., University of Puerto Rico, San Juan.

Standards

New Transformer Standards

A new set of proposed American standards and recommended practices for transformers, regulators, and reactors has just been completed by the sectional committee on transformers of the American Standards Association. The new standards with their appendixes will combine in one volume considerable new material on standards, testing, and operating guides for transformers. It is believed that this will be the most complete single publication of its kind ever compiled. In order to obtain comments and criticisms from the entire industry, these standards are now being published for a 12-month trial period as "Proposed American Standards and Recommended Practices for Trial and Study."

As so much of the material contained in

this proposed standard has already superseded in actual practice the provisions contained in the existing AIEE standards concerned, it has been decided to withdraw from circulation the following AIEE publications: No. 12, "Constant Current Transformers"; No. 13, "Transformers, Induction Regulators, and Reactors"; No. 14, "Instrument Transformers"; No. 100, "Recommendations for the Operation of Transformers"; and the Test Code for Transformers.

Outstanding provisions of the proposed standards include separation of the temperature rise from the ambient and total temperature in order to avoid confusion; establishment of standard impulse insulation levels; inclusion of enlarged guides for operation of transformers with (1) recognition that the name-plate rating and output are not necessarily the same; (2) a new section permitting short-time overloads for both emergency and recurrent conditions set up so that the values permitted will not shorten the life of the transformer; and (3) a change from 40 to 30 degrees centigrade in the average daily ambient temperature at which transformers may be operated continuously for long periods of time. It is possible that the new guides will permit greater outputs under the same service conditions than has been possible in the past. They do not change the rating of transformers for usual service conditions.

The sectional committee on transformers, which is made up of representatives from the AIEE, National Electrical Manufacturers' Association, Edison Electric Institute, Association of American Railroads, and the National Bureau of Standards, has been working for the past four years on these new standards.

In the past, standards for transformers, as well as for rotating machinery, have been devoted largely to setting up specifications for the general principles on which acceptance tests were based, in order that when tests made in accordance with these specifications were completed, the name-plate data for the transformer could be arrived at. To make these new standards more useful to the industry, a somewhat different arrangement of the material has been made, as follows.

The material consists of the standards and two appendixes. The standards are divided into seven sections: (1) definitions; (2) standards common to transformers, regulators, and reactors; (3) standards for distribution and power transformers; (4) standards for instrument transformers; (5) standards for constant-current transformers of the moving-coil type; (6) standards for induction and step-voltage regulators; (7) standards for current limiting reactors.

The two appendixes are: (1) test code for transformers and other induction apparatus; (2) guides for the operation of transformers in service.

The material included in the proposed standards and appendixes was based largely upon AIEE standards Nos. 12, 13, 14, and 100, the NEMA transformer standards, and the AIEE proposed test code for transformers.

The test code previously issued by the AIEE has been enlarged considerably and brought up to date. Complete instructions for making electrical tests are given, together with standard connections used in making heat runs. In cases where two or more methods of making tests or corrections are recognized (as, for instance, when correcting the no-load loss to a sine-wave basis) these methods are outlined in the code. The latest method of making impulse tests is included. The tests are specified by kilovolt instead of by "test gaps" which have been in general use since 1933.

In comparison with AIEE standards earlier than 1930, the new standards are more liberal, in that they recognize overloads which probably more than compensate for whatever restrictions might be imposed under some conditions by reducing the standard ambient from 40 degrees centigrade to a daily average of 30 degrees coupled with a maximum of 40 degrees. As mentioned before, it is possible with the new standards that a greater output may be delivered under the same service conditions. The new standards do not change the rating of transformers for usual service conditions.

This publication, which consists of 100 pages, may be ordered from AIEE headquarters, 33 West 39th Street, New York, N. Y., at a cost of 75 cents net. (The AIEE member discount does not apply.)

Co-ordination of Graphical Symbols. A real need for co-ordination of graphical symbols was pointed out by R. T. Henry at the March 26 standards committee meeting. The sectional committee on graphical symbols, *Z*32, under joint sponsorship of The American Society of Mechanical Engineers and AIEE has been struggling with this problem ever since its organization, but has not as yet found a way to eliminate symbol conflicts. One particular instance was cited—the same symbol is used for contactor and for capacitor. It was finally agreed to advise the sectional committee that the standards committee deprecates the adoption of any American standard containing conflicts in graphical symbols.

Air Switches and Bus Supports. At the March 26, 1940, meeting of the standards committee, K. B. McEachron, chairman of the committee on protective devices of the Institute, submitted a proposed revision of AIEE Standard No. 22. This revision, entitled "Standards for Air Switches and Bus Supports" will, after formal approval by the board of directors, be issued for a trial period of one year. By that time it is hoped it will be possible to add an impulse-test voltage and ten-second wet-test voltage on which complete agreement has not been reached as yet.

Co-ordinating Committee 6 Formed. Announcement was made at the March 26 meeting of the standards committee of the completion of the personnel of standards co-ordinating committee 6, on interference, sound, and noise problems. Members are:

R. G. McCurdy, Bell Telephone Laboratories, Inc., *chairman;* P. L. Alger, General Electric Company; W. F. Davidson, Consolidated Edison Company of New York, Inc.; R. D. Evans, Westinghouse Electric and Manufacturing Company; Gordon Thompson, Electrical Testing Laboratories.

Co-ordinating Committee 7 Planned. It was agreed at the March 26 meeting that standards co-ordinating committee 7 should be organized. This committee, personnel of which has not yet been determined, will cover the general field of conduction in vacuum, gases, solids, and liquids. The co-ordination of ratings of wire and conductors with the ratings of the apparatus they serve may be investigated, as well as such questions as the rating of fuses, circuit breakers, starting circuits, short and overtime ratings, flicker, etc. An exact outline of scope will be determined at a later date.

Electrical and Magnetic Magnitudes and Units. At the March 26 meeting of the standards committee, Professor E. Bennett, University of Wisconsin, was appointed to represent the Institute on the sectional committee on electrical and magnetic magnitudes and units, *C*61. This vacancy has existed since the death of Doctor A. E. Kennelly.

Storage Batteries. The chairmanship of the AIEE delegation on sectional committee *C*40, storage batteries, has been delegated to Harvey N. Stover, battery division, Philco Radio and Television Corporation. The other members of the delegation are C. J. Dempwolf, Carlile and Doughty, Inc., and Ralph Seabury, Delco-Remy division, General Motors Corporation.

Rotating Electrical Machinery. The chairmanship of the AIEE delegation on the sectional committee on rotating electrical machinery, project *C*50, has been delegated to Professor Reinhold Rudenberg, of Harvard University.

Personal • • •

D. C. Prince (A'16, F'26) formerly chief engineer, switchgear department, General Electric Company, Philadelphia, Pa., has been made manager of the commercial engineering department, with headquarters at Schenectady, N. Y. Born February 5, 1891, at Springfield, Ill., he received the degrees of bachelor of science (1912) and master of science (1913) in electrical engineering from the University of Illinois. Following graduation he spent a year with General Electric at Schenectady, as test man and on special problems. From 1914 to 1917 he was employed on valuations and rate-making by the Illinois State Public Utilities Commission, and from 1917 to 1919 was a first lieutenant in the ordnance department of the United States Army. He returned to General Electric in 1919, becoming a research engineer in the radio department in 1920. In 1923 he was assigned to the research laboratory, first on vacuum tube applications, and later as head of the power control section. He went to Philadelphia in 1929 as research engineer of the switchgear department, becoming chief engineer in 1931. He is at present a director of the Institute, a member of the committee on communication, and has been chairman of the Philadelphia Section.

T. H. Hogg (M'31, F'38) chairman and chief engineer of the Ontario Hydro-Electric Power Commission, Toronto, Ont., Can., has been elected president of the Engineering Institute of Canada. He was born April 20, 1884, at Chippawa, Ont., and received the degrees of bachelor of scientific arts in 1908 and of civil engineer in 1914 from the University of Toronto, which also awarded him the honorary degree of doctor of engineering in 1927. He was a member of the engineering staff of the Ontario Power Company, Niagara Falls, Ont., 1902–04, and in 1909 returned to the company as assistant designing engineer and superintendent of construction of the Salmon River development at Pulaski, N. Y. In 1911 he became editor of the *Canadian Engineer*. He went with the Ontario Hydro-Electric Power Commission in 1913 as assistant hydraulic engineer, becoming chief hydraulic engineer in 1924, chief engineer in charge of construction and operation in 1934, and chairman and chief engineer in 1937. He has also been consultant on power projects for the Canadian government and others.

F. B. Hynes (F'31) has been appointed chief engineer of Crocker-Wheeler Electric Manufacturing Company, Ampere, N. J., and will have charge of all engineering and research activities. Born June 16, 1891, he received the degree of mechanical engineer from Cornell University in 1910. He became associated with the Crocker-Wheeler company the same year as specification engineer, becoming successively assistant manager of the specification department, electrical designer on induction motors and alternators, and engineer estimator. In 1915 he was put in charge of engineering and cost estimating and motor applications; in 1918 he was made assistant chief engineer in charge of estimating; and in 1926 he became manager of the engineering department under the chief engineer. In 1930 he was made manager of engineering, in charge of engineering and policy, continuing in that position until his present appointment. He is also a member of the National Electrical Manufacturers' Association.

G. A. Hughes (A'17) has been elected chairman of the board of the Edison General Electric Appliance Company, Chicago, Ill. He had been president of the company since its formation in 1918. He was born April 14, 1871, and attended the University of Minnesota. From 1897 to 1908 he was general manager of the Hughes Electric Company, operating utility properties in North Dakota and Montana. In 1908–09 he was engaged as a manufacturer's agent for electrical apparatus in Chicago, and in 1910 he organized the Hughes Electric Heating Company, of which he was president. The company made and sold the Hughes electric range, which he had invented, until the formation of Edison General Electric in 1918. Mr. Hughes was recently named a "modern pioneer" by the National Association of Manufacturers (*EE, March 1940, p. 171*) for his inventions of heating units.

H. B. Waters (A'04) has been made president of the Telluride Power Company, Salt Lake City, Utah. He was formerly general manager of the company. Born July 19, 1879, he was graduated from the electrical course at Cornell University in 1903 with the degree of mechanical engineer. He was with the Missouri River Power Company in Montana 1903–05, and from 1905 to 1911 was in charge of the mechanical- and electrical-engineering departments of California Polytechnic School, San Luis Obispo, becoming vice-director of the school. In 1911 he became chief engineer for the Beaver River Power Company and Idaho Power and Light Company, later becoming general manager for the Beaver River company and the Southern Utah Power Company. He had been general manager of the Telluride company for over 20 years.

J. H. Gordon, Jr. (M'28) chief engineer, Long Island area, New York Telephone Company, has retired. Born at Washington, D. C., May 13, 1875, he attended Columbian University and Johns Hopkins University, graduating from the latter in 1896 as "proficient in electrical engineering". In 1927 he received the degree of bachelor of engineering from Johns Hopkins. He entered the employ of the New York Telephone Company in 1896, and was successively promoted to the positions of assistant traffic engineer (1901), traffic engineer (1907), superintendent of traffic (1914), assistant general traffic manager (1920). He had been chief engineer for the Long Island area since 1927.

L. L. Crump (M'32) formerly assistant chief engineer, James R. Kearney Corporation, St. Louis, Mo., has been made chief engineer. Born July 20, 1891, at Centralia, Mo., he received the degree of bachelor of science in electrical engineering from the University of Missouri in 1914. After a year as apprentice with the Emerson Electric Manufacturing Company, St. Louis, he became a construction engineer for the Union Electric Light and Power Company, St. Louis, in 1915, continuing with the company until 1930. He was a design engineer for W. N. Matthews Corporation, St. Louis, 1930–31, joining the Kearney company in 1931 as a design and sales engineer.

R. R. Robley (A'18, M'20) formerly superintendent of operations, Portland General Electric Company, Portland, Ore., has been appointed assistant to the vice-president. Born May 31, 1875, in Walla Walla County, Wash., he received the degree of electrical engineer from the University of Oregon in 1901. He was employed by California Gas and Electric Corporation, Santa Rosa, and Columbia Improvement Company, a Stone and Webster subsidiary, before going with Portland General Electric Company in 1904. He has been with the company continuously ever since.

H. P. Sedwick (M'32) has been appointed general manager of the Public Service Company of Northern Illinois, Chicago, Ill. A native (1893) of Arkansas, he studied electrical engineering at the University of Arkansas. He entered the employ of the Public Service Company of Northern Illinois in 1913 as assistant engineer, becoming district engineer in 1917, and district manager in 1921. He was appointed assistant to vice-president in charge of operations in 1923, and in 1933 was made general district manager, the title being changed in the same year to general division manager, in which position he continued until his present appointment.

E. S. McConnell (A'29, M'36) has returned to Anaconda Wire and Cable Company, Hastings-on-Hudson, N. Y., as electrical engineer, after leave of absence with the Copper Wire Engineering Association, Washington, D. C. For the past two years he had charge of field engineering service for the association in the south and east, especially in connection with the rural distribution projects sponsored by the Rural Electrification Administration. During the previous year he was in charge of the preparation of the association's sag and tension charts for overhead copper conductors.

W. H. Fenn (Enrolled Student) University of California, Berkeley, has been awarded one of eight Charles A. Coffin Fellowships granted for research during the academic year 1940–41. He holds the degrees of bachelor of science and master of science from the University of California, and will work there on the application of square-wave voltages to special problems, the production of high-frequency saw-tooth voltages, and their application to the cathode-ray study of ultrahigh-speed phenomena.

H. E. Mahan (A'28) formerly assistant manager in charge of engineering at the illuminating laboratory of the lighting division of General Electric Company, Schenectady, N. Y., has been named manager of the illuminating laboratory section of the division. He has been with the organization since 1910, and has been associated with exposition illumination at the Panama Pacific, Century of Progress, and Golden Gate International expositions.

Gano Dunn (A'91, F'12) president, J. G. White Engineering Corporation, New York, N. Y., has been awarded the Order of Honor and Merit by the government of the Republic of Haiti, for outstanding service in the economic upbuilding of the country. Doctor Dunn, who has received the Hoover and Edison medals and many other honors, was among those recently cited as "Modern Pioneers".

J. S. Moulton (A'22, M'27) who has been assistant to the vice-president and assistant general manager of Pacific Gas and Electric Company, San Francisco, Calif., since 1930, has been promoted to a position in the statistical and rate department, in connection with which he will make system studies and handle regulatory, rate, and valuation matters.

T. F. Barton (A'12, F'30) assistant manager of the New York district, General Electric Company, New York, N. Y., and a vice-president of the AIEE, has been elected third vice-president of the Electrical and Gas Association of New York, Inc. A biographical sketch of Mr. Barton appeared in the March issue, in connection with his nomination as a director of the Institute.

G. T. Shoemaker (M'20, F'39) who has been serving since 1938 as president of the United Light and Power Service Company, Kansas City, Mo., will return to his former position as vice-president of the Kansas City Power and Light Company. He has been associated in engineering and managerial capacities with the United Light and Power Company and its affiliates since 1913.

D. M. Simmons (A'22, F'28) formerly chief engineer, General Cable Corporation, New York, N. Y., has been made a vice-president of the organization as of March 20, 1940. He was recently appointed a director. A biographical sketch of Mr. Simmons appeared in the March issue, page 134.

C. L. Chatham (A'25, M'32) formerly assistant distribution engineer, electric distribution department, Public Service Electric and Gas Company, Newark, N. J., has been made assistant division superintendent of the Passaic division of the department, with headquarters at Paterson, N. J.

H. J. Gille (A'01, M'13) agricultural and industrial development manager, Puget Sound Power and Light Company, Seattle, Wash., has been elected president of the Associated Chambers of Commerce of Washington.

M. E. Lundberg (A'37) manager, Uintah Power and Light Company, Roosevelt, Utah, has been awarded for 1939 the gold key presented annually by the Junior Chamber of Commerce of that community to its outstanding civic leader.

C. C. Musgrove (A'36) who has been representative of the Dallas, Tex., territory for Pacific Electric Manufacturing Company, has been appointed representative for the state of Texas, except El Paso, and for the states of Oklahoma and Louisiana.

F. A. Rogers (A'06, M'28) dean of engineering, Lewis Institute, Chicago, Ill., has been nominated by the Western Society of Engineers to serve as a member of the Washington Award Commission for a three-year term.

G. H. Ikola (A'31) formerly engaged in electrical engineering for the Koppers Company, Pittsburgh, Pa., is now a layout designer for the Douglas Aircraft Company, Santa Monica, Calif.

Obituary • • •

Henry Hutchinson Norris (A'03, M'05, F'12) supervisor of personnel and special instruction, Boston Elevated Railway, Boston, Mass., died April 14, 1940. He was born April 26, 1873, at Philadelphia, Pa. He studied electrical engineering at Johns Hopkins University, where he received in 1894 a diploma as "proficient in electrical engineering," no engineering degree being given there at that time, and at Cornell University, where he received the degree of mechanical engineer in 1896. He was engaged in electrical work for various companies 1890–94. In 1896 he became an instructor in electrical engineering at Cornell University, Ithaca, N. Y., in 1901 assistant professor, in 1905 professor, and from 1909 to 1913 was head of the electrical engineering department. In 1913 he became associate editor of the *Electric Railway Journal*, McGraw-Hill Publishing Company, New York, N. Y., in 1921 managing editor, and in 1923 assistant to the president of the McGraw Hill company. A short time later he became educational advisor to the Boston Elevated Company, Boston, Mass., continuing with the company until his death. He was a manager of the Institute 1909–12, and was also a member of Tau Beta Pi, Sigma Xi, and the Society for Promotion of Engineering Education. In 1904 he was superintendent of tests for the Electric Railway Test Commission, member of the International Jury of Award, and secretary of the group on electrical machinery, at the St. Louis Exposition. He was author and co-author of several books and had written many articles for the technical press.

Hugh Denehy (A'12) assistant consulting electrical engineer, Central Mining and Investment Corporation, Johannesburg, Transvaal, South Africa, died February 21, 1940. He was born April 28, 1883, at Okla, India, and received his technical education at Dalwich College and Northampton Technical Institute, London, Eng. From 1902 to 1905, he was with the Electric Supply Company, Ltd., London, first as an articled pupil, and then as charge engineer. He was a substation engineer for the Metropolitan Railway Company, London, 1905–07. In 1907 he went to South Africa as mains engineer and testing electrician for the South African Railways, Durban, Natal, in 1910 becoming deputy power station engineer for the company. During the period 1908–1911 he was also a lecturer in electrotechnics at the Durban Technical Institute. In 1911 he became chief electrical engineer for the Robinson Gold Mining Company, Ltd., Johannesburg, and was subsequently associated as electrical or resident engineer with various other mining properties in the Transvaal, including the Transvaal Gold Mining Estates, Nourse Mines, Ltd., Modderfontein B Gold Mine and the Central Mining and Investment Corporation. He was also a member of The Institution of Electrical Engineers of Great Britain, the South African Institution of Engineers, South African Institute of Electrical Engineers, and other organizations.

Francis William Clements (A'08) retired chairman of the State Electricity Commission of Victoria, Melbourne, Australia, died December 12, 1939. He was born at Halstead, Essex, England, in 1864, and received his technical education at the City Guilds College, London. From 1881 to 1896 he was associated with the Brush Company, first as pupil and in the contracts department in London, later as representative in Manchester, Eng., and in Hungary, and as joint manager of factories and contract department in Vienna. In 1896 he became engineer and manager of the Bournemouth Electric Supply Company, in England, and in 1898 resident engineer for the County of London. He went to Melbourne, Australia, in 1899 as engineer and manager of the Electric Lighting and Traction Company of Australia, and local managing director and chief engineer of the Adelaide Electric Supply Company. He later became engineer and manager, then chief engineer, manager, and finally managing director and chief engineer of the Melbourne Electric Supply Company, Ltd. About ten years ago he was made a member of the State Electricity Commission of Victoria, and later became chairman of the Commission, continuing in that position until his retirement. He was also a member of the Institution of Electrical Engineers of Great Britain.

Walter Herman Graef (A'08, M'13) electrical contractor, Stapleton, N. Y., died February 20, 1940. He was born August 30, 1872, and studied at Stevens Institute of Technology. He was employed by General Electric Company from 1889 to 1892, first in the test course at Schenectady, N. Y., and later on repair work in New York. From 1893 to 1901 he was associated with the New York Quotation Company, New York and from 1901 to 1904 was with G. and O. Braniff and Company, Mexico City. In 1905 he went to Iquique, Chile, as electrical engineer with J. K. Robinson, agent for Westinghouse Electric and Manufacturing Company, and some years later became electrical engineer for the F. H. Walter Company, Rio de Janeiro, Brazil. He was later a commercial engineer for Westinghouse Electric International Company, Pittsburgh, Pa., before establishing his own business as electrical contractor at Stapleton, N. Y.

Leonard Cook (A'39) electrical instructor, Delgado Central Trades School, New Orleans, La., died recently, according to information just received at Institute headquarters. He was born September 25, 1875, at Clarksville, Tenn., and attended Kentucky Wesleyan College, receiving his technical training by correspondence. He had been engaged in electrical work since 1900, with the Tuggle Electric Company, Beaumont, Tex., 1900–03, and subsequently in New Orleans, being employed at various times by the Barnes Electric Company, National Automatic Fire Alarm Company, J. W. Richardson, National Automatic Electrical Supply Company, and others. From 1913 to 1916 he had his own electrical contracting business, and from 1917 to 1921 was an electrician at the United States Naval Station at New Orleans. He was foreman for the Phoenix Utilities Company 1922–24, and had held his position at the Delgado Central Trades School since 1924.

Paul O'Brien (A'24) assistant chief electrician, New York Hospital, New York, N. Y., died March 10, 1940. He was born August 22, 1901, at Paterson, N. J., and graduated from the New York Electrical School in 1924. In 1922–23 he was general manager of Frederick H. Pruden, Inc., radio firm, Jersey City, N. J., and the following year was employed by the Wappler Electric Company, New York, in the testing laboratory and on sales. In 1924 he became

electrician at the Manhattan Eye, Ear, and Throat Hospital, and following a period as partner in the Yorkville Engineering Company, New York, and as assistant engineer in the McAllister Hotel, Miami, Fla., and the George Washington Hotel, Jacksonville, Fla., he became chief electrician and second assistant engineer at that hospital. He had held his position at New York Hospital since 1932.

Michael A. Horan (A'29) assistant division superintendent, Public Service Electric and Gas Company, Paterson, N. J., died January 19, 1940. He was born May 3, 1886, at New York, N. Y., and educated there. From 1906 to 1915 he was employed by the New York Edison Company, New York, on subway work, in the meter department, and in the mapping and record bureau. Since 1915 he had been with Public Service Electric and Gas Company at Paterson, first engaged in inventory work, and later becoming field engineer, and in 1925 district superintendent. He had held the position of assistant division superintendent for several years.

Membership • •

Recommended for Transfer

The board of examiners, at its meeting on April 18, 1940, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Cory, M. M., professor of electrical engineering, Michigan State College, East Lansing.
Smith, W. L., professor emeritus of electrical engineering, Northeastern University, Boston, Mass.

2 to Grade of Fellow

To Grade of Member

Bailey, E. H., district transformer specialist, General Electric Company, Atlanta, Ga.
Baughn, E., assistant engineer, The Washington Water Power Company, Spokane.
Bruce, R., general superintendent, Memphis Generating Company, Memphis, Tenn.
Calabrese, G., assistant engineer, Consolidated Edison Company of New York, Inc., New York, N. Y.
Davis, J. A., general superintendent, Mesilla Valley Electric Company, Las Cruces, N. Mex.
Denkhaus, W. F., staff engineer, The Bell Telephone Company of Pennsylvania, Philadelphia.
Gross, E. T. B., resident doctor, Cornell University, Ithaca, N. Y.
Herskind, C. C., electrical engineer, General Electric Company, Schenectady, N. Y.
Lovell, T. J., electrical engineer, United States Bureau of Reclamation, Denver, Colo.
Meador, J. R., electrical engineer, General Electric Company, Pittsfield, Mass.
Meagher, J. J., junior engineer, New York and Queens Electric Light and Power Company, Flushing, N. Y.
Mittanck, E. H., engineer, Southwestern Bell Telephone Company, Dallas, Tex.
Rapport, A. H., instructor in electrical engineering, College of the City of New York, New York, N. Y.
Roy, J. A. S., senior electrical engineer, Bureau of Ordnance Navy Department, Washington, D.C.
Shepherd, J. O'D., cost studies engineer, Southern Bell Telephone and Telegraph Company, Atlanta, Ga.
Simpson, W. L., chief electrical engineer, Cia. Carris, Luz & Forca, Rio de Janeiro, Ltd., Brazil.
Snedeker, C. F., assistant engineer, Consolidated Edison Company of New York, Inc., New York N. Y.
Stanley, C. M., Partner, Stanley Engineering Company, Muscatine, Iowa.
Strasbourger, J. C., system load dispatcher, Cleveland Electric Illuminating Company, Cleveland, Ohio.
Taylor, A. Y., consulting engineer, A. Y. Taylor and Company, Clayton, Mo.
Tomlinson, C. M., senior staff engineer, Bell Telephone Company of Pennsylvania, Philadelphia.
Wheeler, K. L., electrical engineer, Cleveland Electric Illuminating Company, Cleveland, Ohio.

22 to Grade of Member.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before May 31, 1940 or July 31, 1940, if the applicant resides outside of the United States or Canada.

United States and Canada

1. North Eastern

Anderson, C. R., 424 Greenwood Place, Syracuse, N. Y.
Chase, L. F., H. E. Stockwell Company, Boston, Mass.
Field, R. F. (Member), General Radio Company, Cambridge, Mass.
Lapinski, C. S., Manning, Maxwell and Moore, Inc., Bridgeport, Conn.
Lind, L. L., Jr., Narragansett Electric Company, Providence, R. I.
McAllister, J. F., General Electric Company, Schenectady, N. Y.
Newquist, R. R., Allis-Chalmers Manufacturing Company, Boston, Mass.
Palmer, A. M., Trumbull Electric Manufacturing Company, Plainville, Conn.
Ryan, J. F. (Member), Eastman Kodak Company, Rochester, N. Y.
Sharp, D. D., Hygrade Sylvania Corporation, Salem, Mass.
Sherry, W. H., J. H. Williams and Company, Buffalo, N. Y.
Summerville, A. O. (Member), Malden Electric Company, Malden, Mass.
Watson, B. P., Massachusetts Institute of Technology, Cambridge.

2. Middle Eastern

Baehr, A. M., 1400 West 25th Street, Cleveland, Ohio.
Bender, J. A., Cleveland Electric Illuminating Company, Cleveland, Ohio.
Benedict, F. R., Westinghouse Electric and Manufacturing Company, Philadelphia, Pa.
Booth, J. D., Westinghouse Electric and Manufacturing Company, Baltimore, Md.
Bowen, P. E., Bell Telephone Company of Pennsylvania, Philadelphia.
Craven, C. L. (Member), Bell Telephone Company of Pennsylvania, Philadelphia.
Cunningham, R. M., Bell Telephone Company of Pennsylvania, Philadelphia.
Dunlap, J. D., Brown Instrument Company, Philadelphia, Pa.
Falkenwald, C. O., Rural Electrification Administration, Washington, D. C.
Farris, W. A., United States Engineer's Office, Cincinnati, Ohio.
Fonda, B. P. (Member), Fonda and Warfield, Baltimore, Md.
Graff, E. W., Philadelphia Electric Company, Springfield, Pa.
Hickok, R. D., Jr., Hickok Electrical Instrument Company, Cleveland, Ohio.
Hollenback, W. L., Hollenback's Radio Supply, Altoona, Pa.
Horstman, C. C., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Lehman, L. G. (Member), University of Pittsburgh, Pittsburgh, Pa.
Mason, R. B., Edward G. Budd Manufacturing Company, Philadelphia, Pa.
Mowery, J. R., Jr., DeWalt Products Corporation, Lancaster, Pa.
Nobles, C. E., Westinghouse Electric and Manufacturing Company, Baltimore, Md.
Opitz, F. M., Consolidated Gas Electric Light and Power Company, Baltimore, Md.
Pierce, R. M., The WGAR Broadcasting Company, Cleveland, Ohio.
Salconi, P. C., Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Md.
Schwalb, R., Hickok Electrical Instruments, Inc., Cleveland, Ohio.
Walters, F. S., Potomac Electric Power Company, Washington, D. C.
Wolff, H. G., United States Government Aircraft Radio Laboratory, Dayton, Ohio.
Wood, W. H., Bell Telephone Company of Pennsylvania, Philadelphia.

3. New York City

Bieling, C. A., Bell Telephone Laboratories, Inc., New York, N. Y.
Carmody, H. A., New York and Queens Electric Light Power Company, Long Island City, N.Y.
Cary, F. L., Consolidated Edison Company of New York, Inc., New York, N. Y.
Koepp, H. A., Western Electric Company, Inc., Kearny, N. J.
Parsons, H. E., Board of Transportation, New York, N. Y.
Weiser, B. M., Scientific Illumination, New York, N. Y.
Wenson, H. W., Board of Transportation, New York, N. Y.

4. Southern

Allen, A. C., Wagner Electric Corporation, Memphis, Tenn.
Beville, J. W., Jr., Florida Power and Light Company, Miami.
Davis, N. K., Georgia Public Service Commission, Atlanta.
Dibble, G. L., Jr., Alabama Power Company, Birmingham.
Finnegan, J. H., United States Navy, Norfolk Navy Yard, Portsmouth, Va.
Gilmer, B. S., Southern Bell Telephone and Telegraph Company, Atlanta, Ga.
Goers, H. J., Aluminum Company of America, Atlanta, Ga.
Leland, W. B., Burlington Mills Corporation, Greensboro, N. C.
Litman, S. W., University of South Carolina, Columbia.
Rader, J. F. (Member), South Carolina Electric and Gas Company, Columbia.
Webb, A. L., Florida Power and Light Company, Miami.
Wilson, M. D., Kentucky-Tennessee Light and Power Company, Bowling Green, Ky.
Wood, A. P. (Member), Louisiana Public Utilities Company, Inc., Franklinton.

5. Great Lakes

Coffin, A. L., Federal Power Commission, Chicago, Ill.
Cox, E. B., Iowa Power Company, Champaign, Ill.
Cutler, B. H. (Member), The L. E. Myers Company, Chicago, Ill.
Dutton, W. C., Allis-Chalmers Company, West Allis, Wis.
Hatch, W. H., Public Service Company of Northern Illinois, Chicago, Ill.
Hazen, D. F., Illinois Iowa Power Company, Champaign, Ill.
Kuether, A. W., Kewaunee Manufacturing Company, Kewaunee, Wis.
Neighbours, R., Commonwealth and Southern Corporation, Jackson, Mich.
Stewart, J. W., Westinghouse Electric and Manufacturing Company, Milwaukee, Wis.
Zimmerman, H. R. (Member), Carnegie Illinois Steel Corporation, Gary, Ind.

6. North Central

Luton, M., Lights and Water Department, Gillette, Wyo.
Porter, E. C. (Member), Rocky Mountain Engineering Company, Denver, Colo.

7. South West

Ezell, A. D., Sun Oil Company, Beaumont, Tex.
Metz, O. F. (Member), Allis-Chalmers Manufacturing Company, El Paso, Tex.
Raudenbush, C., Jefferson College, St. Louis, Mo.
Roth, H. H., Allis-Chalmers Manufacturing Company, El Paso, Tex.
Schoonover, C. E., General Electric Company, Wichita, Kans.
Zalmanzig, F. D., San Antonio Public Service Company, San Antonio, Tex.

. Pacific

Griffin, E. E., Recordall Manufacturing Company, Inc., Los Angeles, Calif.
Guyton, M. E., Pacific Electric Manufacturing Corporation, San Francisco, Calif.
Hart, C. M., Citizens Utilities Company, Kingman, Ariz.
Hatch, J. A., Corps of Engineers, United States Army, Camp Ord, Calif.
Noller, G. W., Underwriters' Laboratories, Inc., San Francisco, Calif.
Sabin, C. J., Phelps Dodge Mines, Bisbee, Ariz.

9. North West

Bryant, W. H., 756 North 81, Seattle, Wash.
Davis, C. R., Montana Power Company, Butte.
Gruber, A., Washington Water Power Company, Spokane.
Klehm, H. I., Washington Water Power Company, Spokane.
Norris, W. V. (Member), University of Oregon, Eugene.
Smith, T. T. (Member), United States Department of Interior, Portland, Ore.

10. Canada

Cowie, N. C., Great Lakes Power Company, Ltd., Sault Sainte Marie, Ont.
Girdwood, A. J., Canadian General Electric Company, Peterborough, Ont.
Goold, C. C. (Member), Bruck Silk Mills, Ltd., Cowansville, Que.
Knowles, G., Canadian Telephones and Supplies, Ltd., Vancouver, B. C.
Mills, F. F., Rolph Clark Stone, Ltd., Toronto, Ont.

Total, United States and Canada, 94

Elsewhere

Chadda, N. S., Jullundur Electric Supply Company, Ltd., Jullundur, Punjab, India.
Das Kalra, R., Lahore Electric Supply Company, Ltd., Lahore, India.
Jeans, A. E. (Member), Electricity Supply Offices, London, W. 4, England.
Mohtadi, M., care Anglo-Iranian Oil Company, Sunbury-on-Thames, England.
Selhi, A. S., B. P. Oil Mills, Agra, India.
Smith, R. (Member), Treasury Department, Monrovia, Liberia, Africa.
Trivedi, H. M., Callender's Cable and Construction Company, Ltd., Ahmedabad, India.
Total, elsewhere, 7